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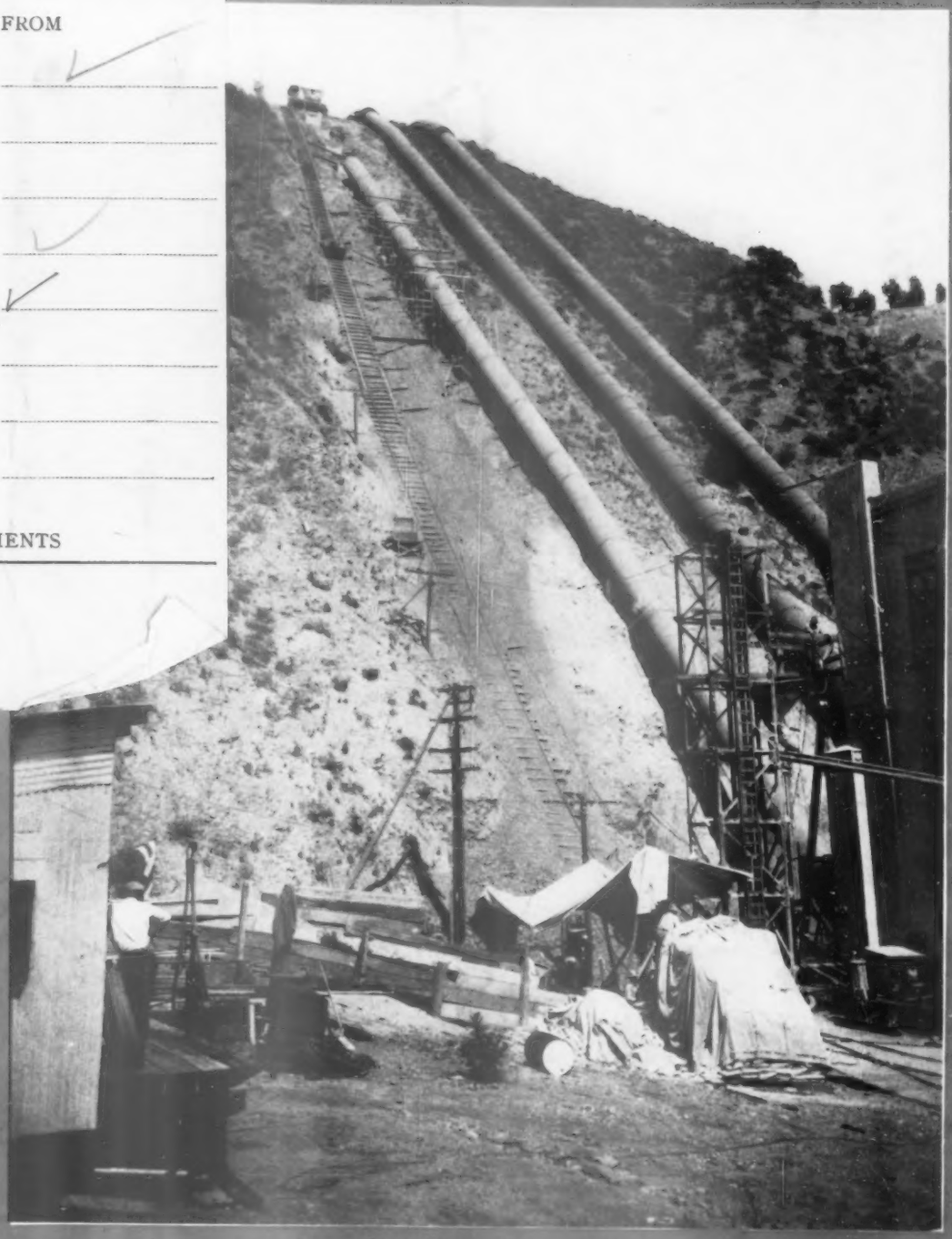

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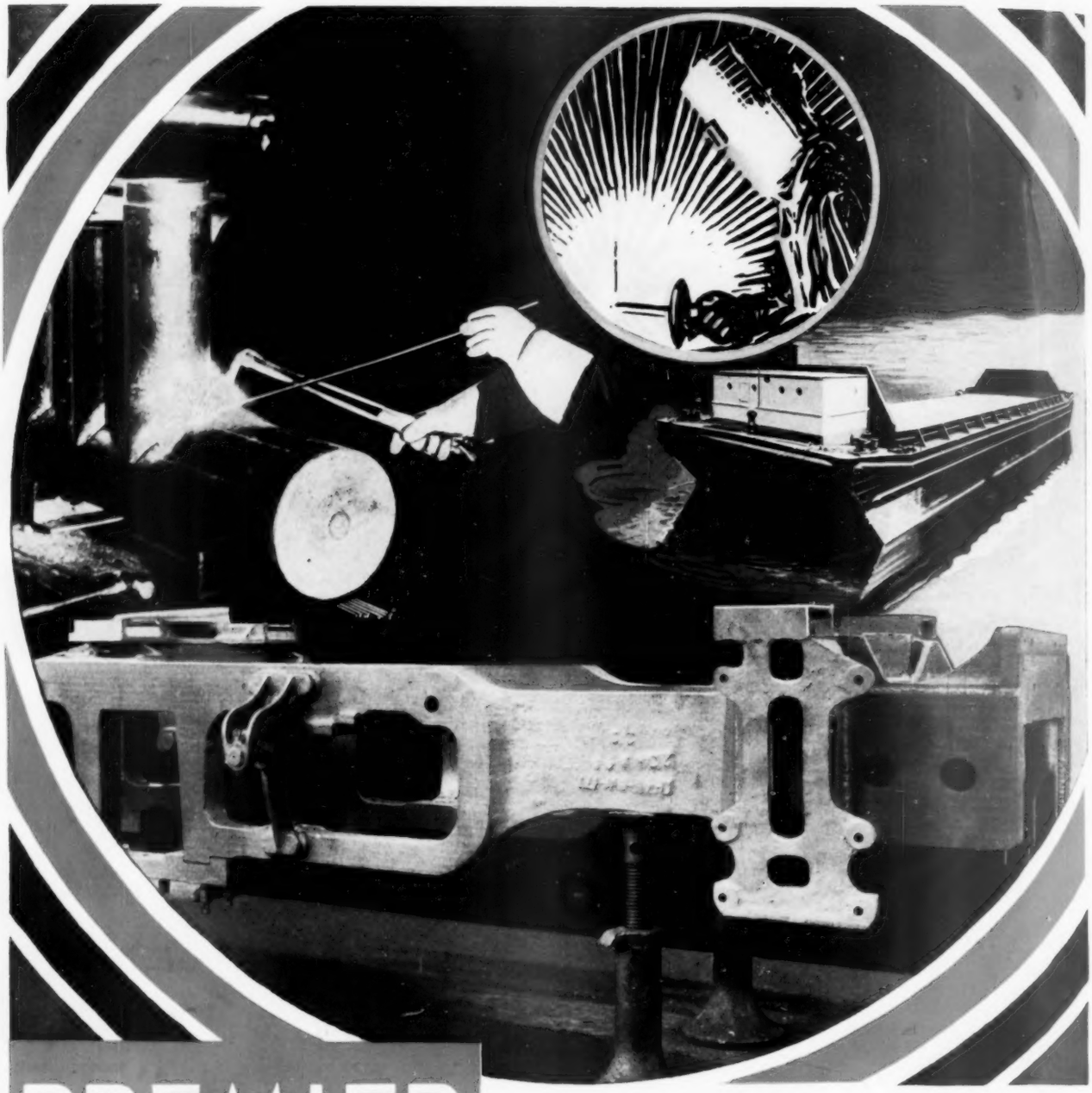

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The Welding Engineer does not publish in its news or advertising columns any matter that deals with or refers to either personal or legal controversies.

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EDITORIAL

The Buffalo Exhibit and Meeting

Though the number and extent of the exhibits at the National Metal Congress in Buffalo this month were small when measured by the standards set by exhibits of other years, it cannot be charged that the show was boresome. Most of the exhibitors had something interesting and original to tell the visitors, including the public, and they told it in such a fashion that the throngs came and gaped and wondered. If the expressions of opinion of a number of the visitors regarding the worthwhileness of the show can be taken as a cross-section of all thought on this matter, the exhibits were a huge success from the public's point of view. Of course there was some disappointment in the matter of the amount of equipment sold by exhibitors, yet most of those exhibiting seemed to recognize the fact that the buyers they have been wanting to reach were there, although they placed orders warily if at all. The fact remains that the managers, purchasing agents, designers, shop employees and others went to a metal exposition and found that welding equipment or welded products were featured in most of the booths, and they left with a vision of the welding industry coming out of the present slough of despond bigger and healthier than ever. Which brings us to the matter of the Welding Society meetings held during the same week. A glance over the audience composed of plant executives, engineers, and technicians from many parts of the country, come to Buffalo to hear an excellent program of papers, revealed no sour countenances or emaciated bodies. Which isn't by way of saying that the industries represented haven't felt the present lassitude in business, for that isn't true. Hard knocks have come as frequently as in most other industries. The welding industry has taken some tough blows on the chin from Kid Depression, but it jumped up before the count and presented the Kid with a recipe for making better and cheaper welds, which blow the Kid can hardly bear under. With heavy-coated wire, then with automatic heads to feed it, and with improved torches and regulators, the industry is showing that research and vision are subduing the most severe economic upset in centuries of history. And Kid Depression himself is becoming groggy.

Steel Industry Turns to Alloy Steels

Alloy steels will be the Moses to lead the steel industry out of the wilderness. Steel-consuming industries are turning to long-lived alloys to replace cheap steels, according to a report of the Iron Alloys Committee of the Engineering Foundation, made public by Frank A. Sisco. The future of the steel industry lies in a turn to quality production rather than the quantity production of the past, says Mr. Sisco, and tremendous improvements and extensions in the manufacture and use of high-quality alloy steels should be forthcoming within the next few years. It is predicted that discoveries will follow within the next five or ten years that will be as important to the public as stainless steel. Of the thousands of possible combinations in alloy steels, only a hundred or so have been developed, according to Mr. Sisco, and all within the past 35 years. The discovery of molybdenum steel made possible the automobile and airplane because of its high strength and weldability. Stainless steel is now being used to a considerable extent in the building industry. The new Hudson River bridge contains several times as much alloy steel as any of the old East River bridges. The attribute of weldability is considered of such great importance to commercial steels and alloys that it will probably be considered as a requirement of all new products of the metallurgical laboratory.

Welded Construction Foreseen for Chicago

THE committee of architects and builders who have been rewriting the building code for Chicago have, after five years of labor, brought in a finished report, in which welding is recognized as safe construction for buildings, as reported elsewhere in this issue of THE WELDING ENGINEER. This is news of the first magnitude for the welding industry. Though under the most favorable circumstances the new code cannot be adopted before three or four months have expired, this will give the builders, structural designers, and contract welders time to post themselves on the requirements of the proposed code, study the literature available on welded structural-steel design, compile cost figures, and in other ways prepare themselves for making intelligent bids wherever welding shows itself to be the superior or cheaper method of fabrication. From two to four pounds of welding rod is consumed for every ton of structural steel in a welded building. When the construction industry gets back into its former stride, this will be a profitable field for the manufacturer of welding equipment.

Your Red Cross and Mine

Many people think that the American Red Cross is in Washington. On the contrary the Red Cross is in every State in the Union; in every one of the 3,600 chapters and 12,000 branches that comprise the domain of the Greatest Mother in the World. In each of these units devoted men and women, without pay, without thought of selfish gain, are today laboring to solve the problems of these troublous times and to make the lots of their less fortunate neighbors easier to bear. In time of disaster, assisted by the financial contributions from national headquarters, and directed by the experts from the national staff, these local chapters carry on relief projects so amazing that but for the fact that American genius for organization is taken for granted, the world would be awed at their extent and magnitude. Garden seed enough to plant 100,000 acres has been given to the victims of flood, drought, tornado and insect plagues in packages weighing approximately five pounds each, and containing some 20 varieties of the best tested seed. This is only one of many ways in which the Red Cross is serving humanity. The membership dues, paid during the annual Roll Call, between Armistice Day and Thanksgiving, finance this program of mercy and relief.

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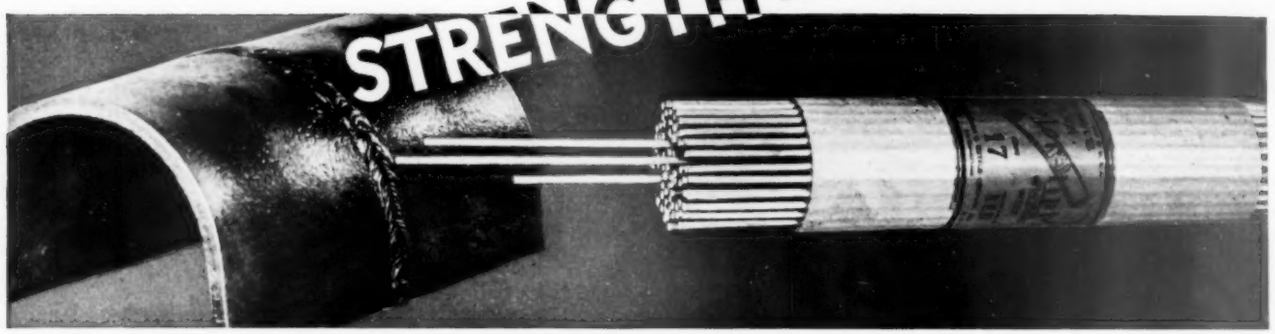

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National Metal Exposition and Fall Meeting of American Welding Society were two of the highlights of National Metal Week

Welding Industry Observes National Metal Week

THE big event of National Metal Week each year is the holding of the National Metal Congress and Exposition, jointly with the annual fall meeting of the American Welding Society and meetings of other groups of engineers and technicians, all with a view to focusing the public's attention on the uses of ferrous and non-ferrous metals and alloys, and to disseminate recent information on the characteristics of metals, their fabrication into useful products, and new applications.

This year the Congress and Exposition was held in Buffalo, N. Y., in the 174th Regiment Armory, during the week beginning October 3rd. The morning technical sessions of the American Welding Society were held in the Fillmore Room in the Hotel Statler, and the afternoon sessions were held at the Armory. These meetings were well attended, and high interest was shown in some of the discussions following the presentation of papers.

A. W. S. Papers

Production Welding

MANY interesting examples of the use of welding in the manufacture of heavy equipment were described in several papers read before the convention. A. E. Gibson, vice-president, The Wellman Engineering Company, showed by means of lantern slides many products fabricated by his company in which welded steel had replaced castings. These included car dumpers, cranes, high-capacity gas producers, telescopic mooring masts, and other heavy equipment.

The general substition of welded rolled steel shapes for castings caused his company to close their iron and steel foundries in 1920, stated Mr. Gibson. Instead of patronizing outside foundries, his company is using rolled steel shapes wherever possible, thereby adding to the production hours in their own shop. As an example of savings in production time and in cost, Mr. Gibson cited the case of a rush order for a small oil-tight gear-reduction unit, which was completely fabricated the day after the order was received, at a cost of $29, compared with a calculated cost of $74 if made in a foundry, which figure includes pattern cost.

Ladles, ladle cars, blast-furnace tuyere jackets, annealing boxes for tin plate, and other heavy equipment used in the iron and steel industry are in some instances being fabricated of rolled steel with welded joints, as pointed out in a paper by Christian A. Wills, of the William B. Pollock Company. Mr. Pollock described the manufacture of a welded open-hearth ladle, having a capacity of 85 tons of hot metal and weighing 21,000 lbs. less than a riveted ladle of the same capacity. This ladle, because of its lighter weight, results in lower crane-handling charges. All parts going into this ladle, including the trunnion pads, were cut from mild-steel slabs or plate; and all the welds were stressed relieved by heating the entire ladle to a temperature of 1200° F. The trunnion pads were riveted to the center section of the ladle, but the remainder of the assembly was welded. Comparison of welded ladle cars with cast ones shows a considerable reduction in weight.

Riveted tin-plate annealing boxes and spelter pans, which are subjected frequently to very high temperatures, soon get out of shape, resulting in leaky seams and loose rivets. Welding of all seams and joints has considerably prolonged the life of such equipment. Mr. Wills named the following blast-furnace parts as having been successfully welded: tuyere jackets, gas-seal hoods, receiving hoppers, downcomers, cold and hot blast mains and gas mains, and in every case savings have resulted.

Electric Welded Gas-Producer Top Plate, Made by The Wellman Engineering Co. The Substitution of Welded Rolled-Steel Shapes for Castings Received Considerable Attention at the Annual A. W. S. Meeting.

A newly developed automatic welding head for feeding heavily coated electrodes into the arc was described in a paper by L. R. Leveen, of the General Electric Company. As the electrode comes from the reel it is fed through multiple feed rolls and past a high-speed cutter which removes a portion of the flux material. The electrode then passes through a current-conducting unit, which comprises five sliding contacts backed up by three pressure rolls to keep the electrode in alignment, and then through a short guiding nozzle to the arc. Typical operations from practice show higher welding speeds than obtained from bare-wire welding, and the welds show the desirable characteristics of heavily coated electrode welds.

In a paper on "Advantages of Thyratron Control for

Resistance Welding," W. C. Hutchins, of the General Electric Company, explained briefly the electrical and mechanical features of this method of control and discussed its application to certain metals and alloys. The Thyratron tube is a tube-type mercury-vapor grid controlled rectifier, and where it is used the mechanical interrupter is replaced by a series transformer wound for line voltage and frequency. This type of control is said to duplicate the duration of any "on" period for which it is adjusted. Used with 60-cycle current, it can be adjusted for an "on" period as low as 1/60 second, which permits the welding of 18-8 stainless steel without the usual formation of carbides and change in structure.

Testing

Set-up, procedure, and data on a welded roof truss were detailed in a paper by Chas. H. Jennings, of the Westinghouse Electric & Manufacturing Company's Research Laboratories. This truss, a description of which appeared in *The Welding Engineer*, August 1932, page 20, is of unusual design in that it employs continuous tension straps, making for a lighter and cheaper structure. Data calculated with tensometers agreed closely with theoretical results. The secondary bending stresses in the various members were found to be relatively low because of the flexibility of the tension members and the joints employed. The straps must be kept straight in fabrication or an undesirable distribution of stress may occur in some of the composite members.

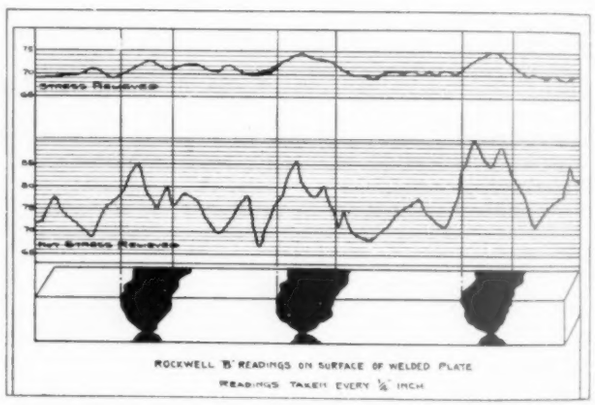
In a paper on "Application of Welding to Pressure Vessels," P. R. Hawthorne, of the Struthers-Wells Company, listed the equipment necessary, and outlined the procedure required, to test vessels built in accordance with the A.S.M.E. Code for Classes 1 and 2 equipment and illustrated his lecture with several types of large arc-welded vessels. In addition to a vast amount of equipment required for the building and testing of Class 1 vessels, the shop organization must be trained in the new method of fabrication, and changes are required in shop methods and the specific duties of shop personnel. The estimating, engineering, and sales organizations must think in terms of a new product made by new and recently developed methods. While X-ray inspection is required for Class 1 vessels but not for Class 2, it is the contention of some that the Code requirements are more rigid for Class 2 welding than for Class 1. Pressure vessels fabricated by welding, with all the safeguards required by codes in their manufacture, and the manufacturer's efforts to establish a reputation for quality work, has been a worthy and commendable factor toward actual insurance against property damage and loss of life, concluded Mr. Hawthorne.

In a paper on "Metallurgy of Welds," by J. C. Holmberg, of the Struthers-Wells Company, considerable emphasis was laid on the important part played by heavily coated rods in obtaining desirable weld characteristics. Attention was given to stress relieving and its effect on the hardness of heavy welded material.

A critical analysis of the use of X-ray diffraction methods for the indication of internal or "locked up" stresses was presented in a paper by John T. Norton, of the Massachusetts Institute of Technology. It is shown that the appearance of asterism in an X-ray photogram does not indicate elastic stresses but rather plastic deformation, or distortion of the grains of the metal. This distortion has the effect of reducing capacity for cold work. The removal of asterism by the stress-relief anneal is discussed. It is suggested that certain other physical properties of metals, in addition to ductility, are dependent upon the perfection of the grains.

Specimens of firebox steel were welded by various processes and the corrosion-fatigue limit of each type of weld determined, with fresh water being used as the corrosion medium and the stresses being of an alternating flexure. The results of these tests were included in a paper by W. E. Harvey and F. Jerome Whitney, Jr., both of Lehigh University. In the gas, arc, and atomic-hydrogen welds, the corrosion-fatigue limit was higher than the fatigue limit in air of the same material, while in the electric resistance welds the values were approximately the same. In every case, except one, the corrosion-fatigue limit was higher for the welded material than for firebox steel unwelded. This was interpreted to mean that the parent metal is anodic to the weld metal in the type of fresh water used.

The results of strain-gage determinations of stress distributions in welded butt-strap connections were presented in a paper by S. C. Hollister and A. S. Gelman, both of Purdue University, in which was emphasized the necessity of stress uniformity along the weld in members subjected to alternate or repeated loading. The results of a

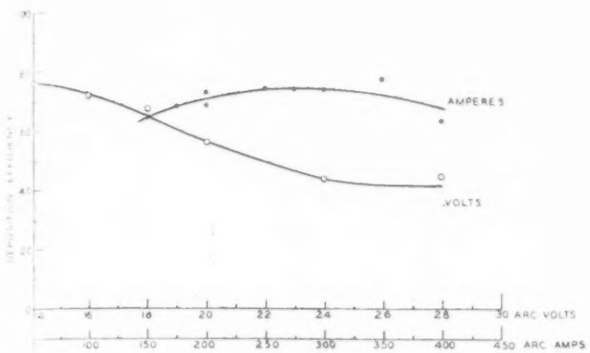


Graph Plotted From Rockwell "B" Readings Before and After Stress-Relieving at 1200 Deg. F. Readings Were Taken Every Quarter Inch. From Paper by J. C. Holmberg.

comparison of tests with different shapes of butt straps do not favor the use of butt straps welded along the sides only (the welds being thus in longitudinal shear) in members subjected to stress variation.

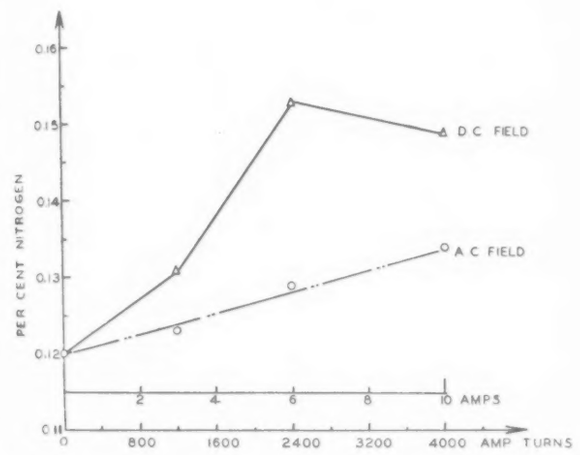
In a paper on "Pre-Qualification Tests for Welders," Ernest Lunn pointed out that in some localities established codes lay down regulations which must be followed in making qualification tests of welders, but where such codes do not exist somewhat simpler and less expensive tests will be found useful in the selection of welders for work where weld quality is important. These tests also have the effect of assisting the welder in determining his ability to make satisfactory welds. Such qualification tests should begin with an examination of the welder as to training, experience, and actual knowledge of important fundamentals and of the operating characteristics of welding equipment. This should be followed by a test for weld quality, using such equipment and materials as will be used on the job and in all positions required by the work to be done. The test piece should be broken through the weld and the

weld metal examined. The welder then should make up samples for tensile test under conditions identical with those governing the work to be done, these furnishing a quantitative basis for grading his ability. Complete records of the welder's experience and of the procedure and results of all tests should be kept.



Effect of Varying Volts and Amperes on Deposition Efficiency With a Constant A.C. Field of 2400 Ampere-Turns Parallel to the Arc.

Welders should be qualified not only as regards skill but also in accordance with experience, said Vincent P. Marran, of the Walsh Holyoke Steam Boiler Works, Inc., in a paper on "Qualifications for Welders." Welders who are qualified for sheet-metal work may not have the necessary experience and skill to work on pressure vessels or



Effect of A.C. and D.C. Fields of Varying Intensities on the Nitrogen Content of the Metallic Electrode Arc Deposit.

on heavy metals. Therefore, Mr. Marran suggested, qualifications should be according to A, B, C, and D grades, these referring respectively to sheet metals, heavier metals, pressure vessels, and boilers, the requirements being more rigid as the welder passes from one grade to the next higher.

Metal Deposition in the Arc

A new method of studying the transfer of metal in the electric arc, together with results, was described in a paper by Gilbert E. Doan, of Lehigh University, and J. Murray Weed, of the General Electric Company. A polished strip of ¼-in. mild steel was set in an automatic welding machine, and a welding arc was advanced along the strip at a rate exceeding 100 in. per minute. The deposits from the electrode wire were nicely separated along the steel strip, and oscillograms of voltage and current were taken at the same time. Examination of the deposited globules and comparison with the oscillographic records reveal that the latter records the action of the depositing mechanism very accurately. The electrodes used were bare or only lightly coated. The experiments indicate that liquid globules are the chief form of metal transfer, although some metal is transferred as vapor and mist. It was suggested that this method be used to compare the depositing performance or "weldability" of various types of electrodes.

The composition of deposited arc weld metal can be changed at will by varying the nature or thickness of surface coatings or coverings of the electrode or by changing the length of the arc, pointed out J. C. Hodge, of the Babcock & Wilcox Company, in a paper on "The Chemistry of Low-Carbon Metal-Arc Weld Metals." An examination of the deposited metal reveals nitrogen contents varying from 0.015 to 0.15, depending upon the degree of protection. The nitrogen content was considered to be the criterion of the efficiency of protection. During deposition, the carbon and manganese contents are considerably lowered, these values also being dependent on the degree of protection of the arc. It is believed that these changes in chemical composition affect the elastic properties of the metals and their behavior under plastic deformation throughout the entire temperature range.

Direct-current and alternating-current magnetic fields of different strengths were directed parallel to an iron arc, and the results noted for deposition efficiency, chemical analysis of the weld metal, and spread and penetration. Description of the apparatus used and the test results were given in a paper prepared by F. R. Hensel and W. A. Maddox, of the Research Laboratories of the Westinghouse Electric & Manufacturing Company. By this method, the arc blow was corrected by an alternating-current field and still about 70% deposition efficiency obtained. Spread and penetration were affected much more with alternating-current fields than with direct-current fields, and the nitrogen absorption was higher with direct-current fields than with alternating-current fields.

Welding Non-Ferrous Alloys and Metals

"Lead Burning or Welding," a paper by Robert L. Ziegfield, of the Lead Industries Association, gave in detail the welding procedure to be employed and the type of equipment used to weld various grades of lead. The author also discussed at length some of the fields in which lead welding is being applied. This paper is printed elsewhere in this issue of *The Welding Engineer*.

Recent improvements and developments in the electric welding of high-nickel alloys, such as monel metal, nickel, Inco-Chrome nickel, and nickel-clad steel, resulting in superior physical properties, were brought out in a paper by J. G. Shoener and F. G. Flocke, of The International Nickel Company, Inc. Laboratory work and field practice were discussed, and typical applications were described, these including nickel and nickel-clad caustic evaporators, Inco-Chrome nickel dairy machinery, and monel-metal chemical equipment.

In a talk on "Selling Welded Products," T. C. Fetherston, of The Linde Air Products Company, pointed out the need for intelligent cooperation between the manufacturer of welded products, the distributor, and the buyer. He urged that welded products be advertised as

such, and pointed out that many manufacturers and sales agents are emphasizing "welded construction" in their sales literature as an aid in breaking down sales resistance.

In a paper on "Automobile Repair Welding," A. F. Keogh, of the Sound Welding Company, described the processes used by the modern repair and service station in the repairing of passenger cars, trucks, and buses. The welding of aluminum, malleable iron, castings, etc., was discussed, and Mr. Keogh spoke of the advantages of solder in repair work, applied by the torch or the iron. Information was given on the application of hard-surfacing materials to wearing parts.

Cutting

The cutting torch is both a destructive and a creative agent, as shown in two papers relating to oxyacetylene cutting. W. H. Ludington, of the Air Reduction Sales Company, discussed the use of the cutting torch in scrapping railroad rolling stock. Available data showed an average consumption of 300 cu. ft. of oxygen and 70 cu. ft. of acetylene in the scrapping of wooden box cars, 770 cu. ft. of oxygen and 190 cu. ft. of acetylene for flat cars, and 1150 cu. ft. of oxygen and 290 cu. ft. of acetylene for all-steel gondolas. One railroad shows an average total cost of $25.77 per car, and labor of 24 man-hours per car, with 19 men engaged in the work, six of whom are torch operators.

The application of the oxyacetylene torch to the rough machining of steel was well covered in a paper on "Conditioning, Shaping and Machining of Carbon Steel with Oxygen," by H. H. Moss, of The Linde Air Products Company. Examples were cited of the use of the cutting torch for planing, milling, turning, punching, and boring. The same nozzles are used as in normal cutting, but a relatively low oxygen velocity is required.

Metal Spraying

A paper by H. B. Rice, of the Metal Spray Company, opened with a history of the development of the metal spraying process, and described some of the equipment at present being used. Many kinds of metals can be applied by this process, and one metal can be deposited on another. The purpose of this process may be to apply a thin protective or decorative coat, or to apply thick coats to build up worn surfaces or for resistance to abrasion or corrosion. The first use requires soft metals principally, while the second use employs hard or high-melting-point metals to a larger extent. Many examples were given of applications. When using ⅛-in. rods, which may be applied at the rate of 6 lb. per hour, the total cost including metal, oxygen, acetylene, and labor will approximate 50 cents per pound for the cheaper steels and $1.00 per pound for the various stainless steels or for monel, it was stated. One pound of any of these metals sprayed upon one square foot or area will obtain a coating about 0.025 in. thick. Gun operation may be learned in a few hours, and compares in operating skill with a cutting torch. Average applications may be made immediately but some experience must be acquired before attempting some of the more difficult deposits. The surface should be roughened by sand blasting before being sprayed, and the bond obtained is very intimate but purely mechanical. Warpage of the object receiving the deposit does not take place as in welding.

Exhibits

THE important part played by welding in modern industry was strikingly illustrated by the exhibits at the National Metal Exposition, a large proportion of which showed working displays of welding processes or products fabricated by welding. As a result of interest in heavy-coated electric welding wire, quite a number of manufacturers who have developed heavy coated electrodes had these new products on display, and demonstrated them in welding booths to allow visitors to watch the operation of the arc.

One manufacturer of heavy-coated wire had on display for the first time an automatic welding machine with which such wire was being used. Other recent developments in arc-welding machines were also in evidence, and a number of the steel companies showed welded specimens of steel and its various alloys as well as non-ferrous metals.

In the oxy-acetylene welding field one manufacturer showed for the first time a new, light-weight torch equipped with a special valve and a thumb control lever permitting unusually quick and accurate control. A new two-stage regulator was also shown for the first time, this permitting a very high precision of regulation over the entire range of cylinder pressures and containing a signalling device which indicates in case of a defective seat in the high-pressure stage.

Automatic cutting torches of various types were also on display, one of these being a new development in the field and was shown in operation. There was also in operation a pipe cutting torch for beveling pipe preparatory to welding.

One of the hard-facing companies had on exhibit a tool faced with their product and engaged in cutting a metal shaft in a lathe. A torch was kept continually playing against this tool, keeping it red hot, thereby demonstrating the red hardness of the material used.

One of the displays at the exhibit which attracted a great amount of attention was a metal spray gun, the operator of which was kept busy spraying aluminum and other metals on to plaster images, glass bottles, metallic ornaments, on the backs of visitors' business cards and, in fact, on any clean surface.

Materials used in the art of thermit welding were also on display. One manufacturer of resistance welding equipment exhibited spot welders ranging in size from ½ to 35 k.w.

Two companies in the fabricating field had special exhibits showing welds conforming to the A.S.M.E. Code for welding Class 1 and Class 2 pressure vessels. The function of the X-ray in testing welds was shown by means of a display of photographs in one of the booths.

A small, portable tensile testing machine was on display, and several manufacturers of laboratory equipment showed some new machines for the analysis of iron and steel by means of a spectograph, as well as polariscopes for determining points of strain by the use of celluloid models. Various types of Brinell hardness testers were also on display.

One booth showed a new metal degreasing machine that is applicable to the cleaning of castings, steel shapes, etc., before welding.

The Vocational High Schools of Buffalo had an extensive exhibit showing students' work. Many samples

of welding were shown, and gas welding was demonstrated. A part of the exhibit was devoted to airplane welding and another section to the layout and welding of pipe and pipe fittings.

Efficiency of Composite Joints

By James W. Owens
Consulting Engineer

A SERIES of tests to determine the relative shear values of riveted, welded, and composite joints, made by Sterling Johnson, of the McClintic-Marshall Corp., and given in the August, 1932, issue of THE WELDING ENGINEER, are timely, as there are some engineers who, unlike Mr. Johnson, would exclude the use of the composite joint under any conditions. There was a time when it was desirable and necessary to take this stand in both new construction and repair. However, I feel that this time has not only passed, but that there is a very definite field for the composite joint both in new construction and in repair. This conclusion is based on a few tests of my own, which have been made from time to time, on the tests of other investigators, and on my successful use of this joint.

In the past, a prohibition on the use of the composite joint in new construction was at times the only way to compel the designer to think in terms of welding, and to prevent excessively high costs of fabrication due to the welding of riveted joints which had not been specially redesigned as composite joints. When not prohibited in repair work the composite joint would frequently fail because the weld was made too small to carry the load in joints wherein the rivets were loose or the joints overloaded.

I was particularly interested in Mr. Johnson's statement that his tests were undertaken because "no test data showing the efficiency of such a combination [the composite joint] was known to be available." As it happens, tests of composite joints were among the earliest made. The two outstanding examples were those made in 1917 by Quasi-Arc, Inc., in England, and by William T. Bonner in the United States. The Quasi Arc specimens were 12 in. wide, and the Bonner specimens were 8 to 10 in. wide. Both series of tests were reported in 1918 to the Welding Committee of the Emergency Fleet Corporation.

Mr. Bonner's specimens were tested at the U. S. Bureau of Standards, and the results were briefly summarized in the curves shown in Fig. 157 of my book "Fundamentals of Welding." These tests indicated that: a light fillet weld (in transverse shear) on one edge of a Lloyd's single-riveted lap joint would increase the efficiency of the joint from 52% to 71%; and that a full fillet weld would only increase it about 4% more, or to 75%. The efficiency of Lloyd's double-riveted lap as shown by these tests was 77%.

My attitude on the composite joint can best be expressed by quoting from my remarks on this subject in my discussion of H. W. Pierce's paper on "Arc Welding in Ship Building," given in the Transactions of the Society of Naval Architects and Marine Engineers, 1931. Mr. Pierce stated that "the combination of riveting and welding in a strength joint had been banned—for, if the weld is designed to carry only a part [of the load], it will fail under the greater load imposed by initial rivet slippage." My comments on this statement were to the effect that "although I much prefer to use a completely welded joint, nevertheless, a joint wherein both riveting and welding are used can be so designed that both the rivet and the weld will take their proportionate share of the load without the initial rivet slippage as stated by Mr. Pierce. Such a joint is sometimes desirable in new construction and frequently essential in repair; therefore, it cannot at present be arbitrarily excluded. Entirely wrong conclusions of the composite joint have, in my opinion, been drawn by the use of light caulking welds on joints with loose rivets, thus requiring the welds to take the entire working load. On such joints and in new construction, the minimum strength of the weld should be greater than the maximum working load which the joint will be required to stand, and preferably, the combined strength of rivets and welds should be greater than the yield point of the base metal."

The results of Mr. Johnson's tests not only tend to strengthen my conclusions, but should encourage the proper use of this joint.

* * *

[Editor's Note: Mr. Johnson's article in the August issue and Mr. Owen's comments given above should aid in clarifying some disputed points and misapprehensions regarding the value of the welded-riveted joint. For 14 years Mr. Owens pioneered in the development and use of the welding and cutting processes. This research and most of his welding experience were obtained as Welding Aide for the Bureau of Construction and Repair of the U. S. Navy, and as Director of Welding for the Newport News Shipbuilding & Dry Dock Company. The American Welding Society recognized his services to the welding industry when it awarded its Miller Memorial Medal to him in 1929, and he was the recipient of the first prize of $10,000 in the first Lincoln Electric Company's international competition for papers on welding. That Mr. Owens, an internationally known authority on welding, should favor the combined welded and riveted joint over the all-welded joint in many applications is not at all surprising, for, as he says, "to me all processes, whether thermal or mechanical, are only the means to an end, the choice of any process or combination of processes being dependent on the results to be accomplished."]

Program of Institution of Welding Engineers

The Institution of Welding Engineers (London) has issued its programs for the 1932-33 season. The first meeting in London will be held on October 19th, with an illustrated lecture on "The Radiographic Examination of Welds," by R. A. Stephen, to be followed on November 16th with a paper on "Cutting Steel With Oxygen Machines," by C. G. Bainbridge. The Birmingham program opens with the Chairman's address on October 14th, and at the November 18th meeting R. R. Butler will read a paper on "Eye Protection During Welding Operations." The Institution opened its Manchester program with a paper on "The Testing of Fusion Welds in the Laboratory," by L. W. Schuster, on September 28th, to be followed by the showing of a new film on "Oxy-Acetylene Welding" on October 12th, a paper on "Atomic-Hydrogen Welding" by J. Dorritt on October 26th, and a paper on "Flame Cutting by Hand and Machine," by C. G. Bainbridge on November 30th.

George Westinghouse Memorial Bridge

Concrete Bridge Utilities Welded Reinforcement

By L. R. Canfield
Advertising Department, Westinghouse Electric & Manufacturing Company

Splicing reinforcing rods by welding allows considerable reduction in size of all key positions

THE new George Westinghouse bridge, a part of the Lincoln Highway improvement crossing the busy industrial valley at East Pittsburgh, Pa., has a number of unusual design details and includes arc welding as a major element in the construction of its arch reinforcing structures, primarily because fusion welding was the only method that was practicable in fabricating a structure of this huge size (one of its five open spandrel ribbed-type arches spans a distance of 425 ft.).

In the design of this type of bridge, several key positions or spaces must be left at intervals in the concrete forms of each arch, to be filled in after the concrete is all "set" in the adjacent sections. This is done in order to allow for changes in volume during hardening of those sections. The size and type of this bridge called for at least three key positions in each of its ten arch ribs; and in order that the key positions, when filled in, be forever as rigid as the rest of the rib, they should be made as small as practicable.

If the usual method of splicing the reinforcing steel bars in bridges of this type were employed, it would call for about a 10-ft. space for the key positions. The rods would then be clamped and wired for a distance of about 6 ft. in order to insure a positive splice. In the George Westinghouse bridge, the stresses are positively transferred through a 12-in. arc-welded joint, stronger than the rod itself; and the total key position space, ample for access in welding, is only 4 ft.

A typical key-position section in which a welder is working, is shown in Fig. 1. The irregular contour of the end surfaces of the adjacent sections assures a tight

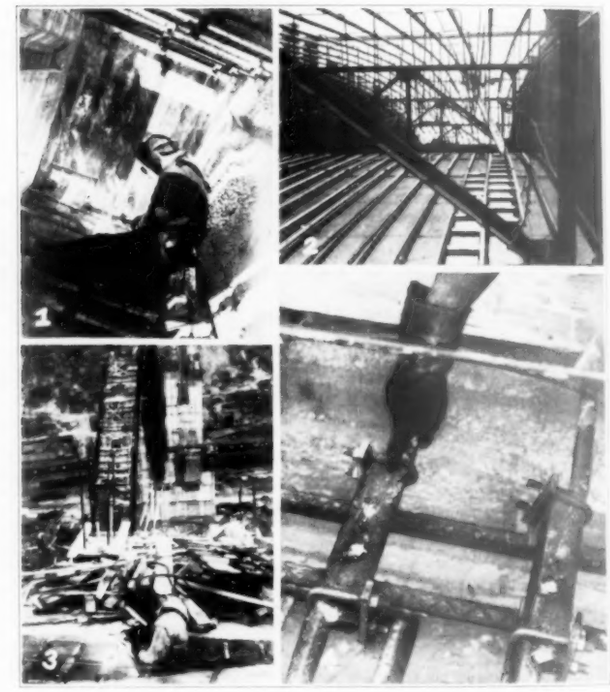


Fig. 1. Arc Welder at Work in a Key Position.
Fig. 2. Showing Rod-Bracing Forms and Reinforcing System.
Fig. 3. Splicing Upper Row of Reinforcing Bars at a Key Position.
Fig. 4. A Closeup View of a Top Row Splice.

lock with the small section composing the key-position concrete when this section is poured.

All ribs, except those of the large center span, contain fourteen 1¼-in.-square rods along the top and bottom—a total of twenty-eight. The two center arch ribs contain seventeen at top and bottom. As erected, the reinforcing rods were spaced in steel frames located 15 to 25 ft. apart and were temporarily spliced with wire. Fig. 2 shows a view looking up a center-arch rib inside the form. Splices which occur within the main sections (not at the key positions) were made by clamping and wrapping with wire for a length of more than 6 ft.

In all but the center span, a key position was located at the pier skew-back, connecting the dowels from each abutment. In the center-span ribs, the reinforcing rods

were clamped and welded to the dowels before the forms were completed; the concrete was then filled in for the bottom section right to the pier skew-back. In Fig. 3 a welder is shown making one of the upper key splices.

Data used in the design of the welded key-position joints were obtained from a series of special tests. The joints were designed to have greater strength than the rods themselves. They were made even more rigid and conservative by introducing the cross-bar bracing system, in which two bars were welded across the ends of the joints of both top and bottom reinforcing rods. These bars are visible in Fig. 4, running crosswise under the reinforcing rods, and their details, including location of welds, are shown in Fig. 5.

All welding was done with $\frac{3}{16}$-in. sulcoat, mild-steel electrodes, using a current of 200 amperes. A gas-engine-driven 200-ampere FlexArc welder supplied the current for the entire job. All joints were thoroughly inspected to assure uniformity of surface, thorough penetration, absence of burned metal, and correct fillet size.

The making of the key-position splices necessarily had

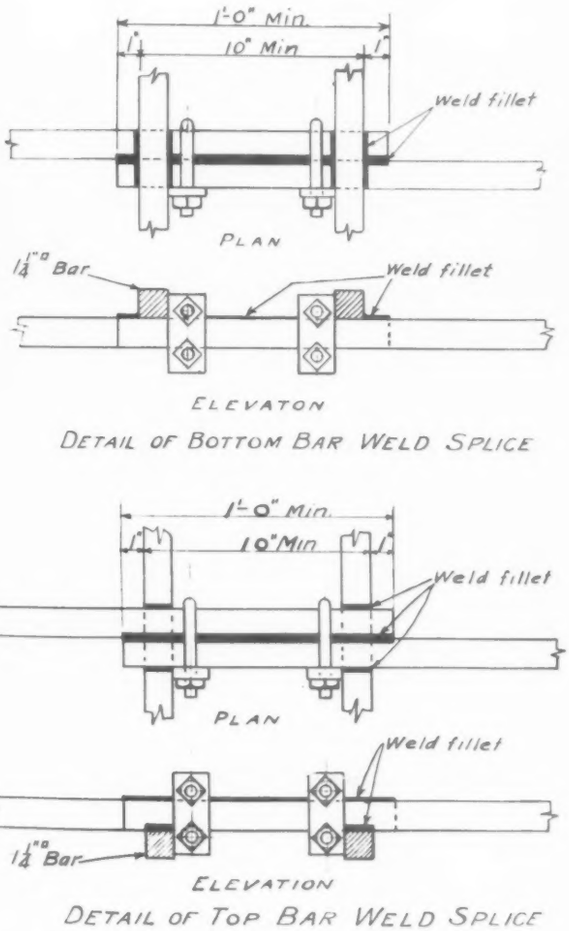


Fig. 5. Detail of Top and Bottom Bar Weld Splices.

to await the "setting" of the concrete in the adjacent sections, or approximately five days after the concrete in a rib had been poured.

The joining rods were fastened near their ends with U-bolt clamps, shown plainly in Fig. 4. It so happened that at least one of the two bars to be joined was twisted slightly so as to form a desirable V-section for greater contact surface in fusion.

A burn-in bead was first made along the line of contact of the two bars, on the top side. Then a wider bead was weaved in over the burn-in weld, giving a solid fillet with a throat dimension of approximately $\frac{1}{2}$ in. and in most cases a width of about $\frac{3}{4}$ in. The lengths of the fillets for key-position joints were a minimum of 12 in.

Each cross-bar connection was made on both sides, as shown in Fig. 5, the welds being $1\frac{1}{4}$ in. fillets for the top-row connections and $2\frac{1}{2}$-in. fillets for the bottom row. The U-bolt clamps were left on the rods after welding was completed.

Another application of arc welding in the construction of the George Westinghouse bridge was the fabrication

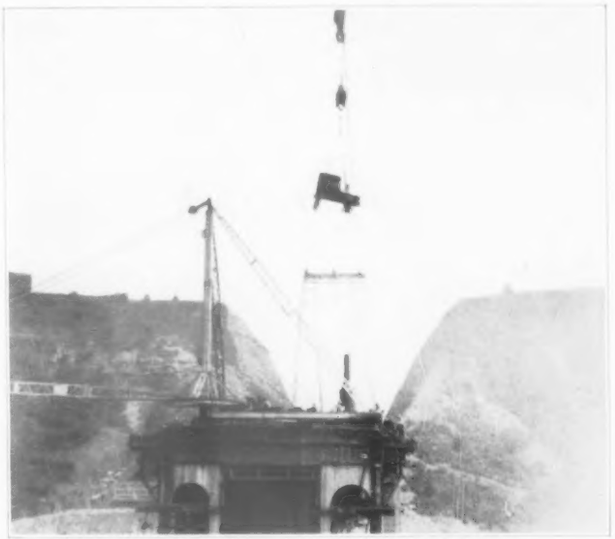


Fig. 6. The Overhead Cableway Carries the Welding Machine to a Machinery Repair Job.

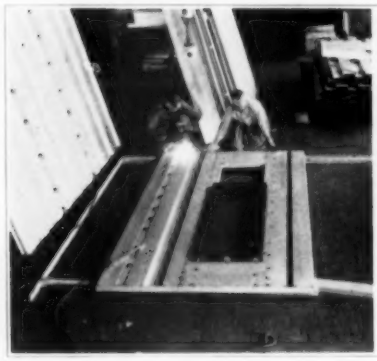
of the steel struts for supporting the bulkheads during the pouring of alternate sections of a rib. These struts consisted of a 10-in. I-beam with a square 1-in. steel plate, or bearing shoe, welded to each end.

A "high-line" running over the bridge carried many thousands of tons of concrete, steel, lumber and other materials which went into the construction of this unusual structure. Occasionally it also lifted a small arc welding machine and carried it from its duties at a key position on an arch, or under it, to a disabled cement mixer or some such machine perhaps a thousand feet away, and in a fraction of an hour the electric arc had reclaimed the broken part.

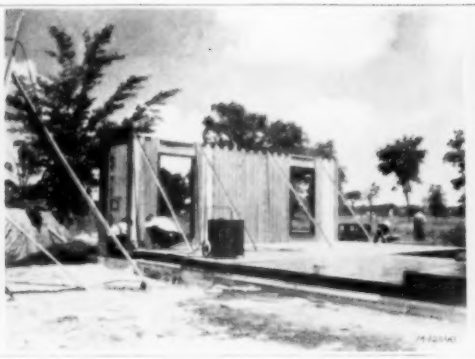
The Allegheny County Department of Public Works were the designers of this outstanding bridge. Contractors for the job were the Booth & Flinn Company of Pittsburgh.

Giant Fuel Storage Tank Built By Arc Welding

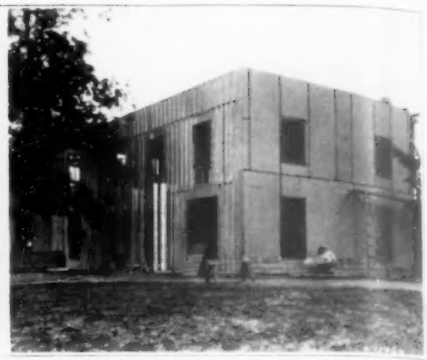
A 14,000-gallon oil storage tank was recently fabricated by the shielded-arc process of welding by The Steel Plate Construction Company of Portland, Oregon. Built for the federal government, it was put in place 15 ft. below the ground to serve as an oil storage container for the new federal building under construction at Portland. The tank is 9 ft. in diameter, 28 ft. long, and weighs 7 tons.



Shop fabricating a wall section, containing a window pane welded in place. The corrugated panels allow for great flexibility in erecting the sections on the building site.



Erecting a side wall of the new frameless steel house. Each section is clamped in place and quickly welded with an a-c. welder especially designed for welding sheet steel.



Porcelain-enameled shingles being nailed over the one-inch-thick Celotex. Note the mastic seams on the Celotex insulation layer.

Frameless All-Steel House

Constructed of Welded Sheet-Metal Sections

Unique construction allows complete shop fabrication and erection in only fifteen days

THE first frameless steel house built by a newly developed type of construction was dedicated by fitting ceremonies at Solon, Ohio, where this house was erected, on the afternoon of October 12th. For this type of construction, in which welding plays an indispensible part, the following advantages are claimed:

(1) Houses can be completed in 15 days. No long period in which capital is unproductively tied up.

(2) Fire-resistant. No dwelling insurance necessary.

(3) Vermin-proof.

(4) Low-cost construction.

(5) Low maintenance. No painting necessary. No wood to decay.

(6) Low fuel consumption, due to scientific insulation.

(7) Lightning-proof.

This "skin supported," all-steel, all-welded house is attractive in appearance, comfortable to live in, and inexpensive to construct and finance.

The surprising low erection costs were brought about by the use of welded corrugated sheet-steel walls as the frame, factory assembly of walls and floors, alternating-current welding, colored porcelain-enamel shingles, new materials such as Micarta, and carefully pre-engineered constructional details. The absence of screen doors, and the possibility of heating this fireproof house by blowing air into the honey-comb openings of the floors and walls, thus creating a blanket of warm air about each room, demonstrate the most advanced ideas of home comfort.

The house comprising 2 stories and 8 rooms, with a solarium on its flat porch-like top, is built entirely of sheet steel, sound-proofed, and thermally insulated. The exterior construction consists essentially of 1-in. thick Celotex sheathed with colored porcelain-enamel shingles, which eliminate all need for painting for all time, both nailed to the sheet-metal walls. Wall board and plaster, with colored Micarta base board, are used for the interior finish. The steel floors are coated with a layer of mastic to serve as a sound deadener and as an adhesive for the floor covering. Ceilings are of acoustical tile.

This type of frameless house requires only 17 tons of steel—much less than comparable houses of the steel-frame type. Sections of three standard widths and of any length, made of 20-gage steel with box-like corrugations, are the main constructional elements. After rust-proofing, the units are welded together in the factory to form story-high, room-wide sections with metal window frames and spandrels welded in place.

Similarly, rolled steel sheets, pressed into Z sections, were welded into floor assemblies at the factory. These wall and floor spans were then hauled to the site for erection by arc welding. Although the completed walls do not exceed 3 in. in thickness, they possess unusual insulating qualities. Since the walls themselves constitute the frame, no structural work is required.

Walls

The sheets for the walls are cut to the desired length at the factory. Two different lengths are used—one for the first story and one for the second. The box-like corrugations, or channels, pressed into the sheets have a 6-in. web with a 2-in. leg. After forming, the sheets are of three different widths—1 ft. 1 in., 2 ft. 1 in., and 3 ft. 1 in. The extra inch affords a welding surface.

In the wall assembly, the section containing the 16-gage furniture steel window frame and spandrels was first assembled, with additional wall sheets welded as

needed, to complete the side of the room. Welds were made at approximately 12-in. intervals, with about five seconds' time required to complete a weld.

There was absolutely no cutting or fitting. When necessary, the channeled wall sheets are overlapped, such construction being the first to provide adequate flexibility. If a wall section 9 ft. 6 in. wide is being assembled, three of the 3 ft. 1 in. and one 1 ft. 1 in. channeled sections would be used. Two of the wall sheets would be lapped one channel, forming a 6-in. hollow column, which strengthens the structure.

After a wall section is assembled, header strip 2 in. wide, of 16-gage hot-rolled steel, is welded to the top and bottom to give rigidity.

After factory assembly, the large wall sections were numbered and hauled to the site like stage scenery. The average weight per square foot of wall was 2.91 lb.

Floors

Eighteen-gage hot-rolled steel sheets were used in the floors. The 28-in. wide material was sheared to length in the steel mill. Fabrication was an extremely simple process. Each sheet was formed into a "Z" shape, having the two parallel lines, or legs, 11 in. long, and the vertical line, or web, 6 in. high. These Z sheets were lapped 1 in. longitudinally, and arc welded at approximately 24 in. intervals at both points of contact. This formed a honeycomb of metal boxes 6 in. deep by 10 in. wide, which are structurally flexible, light in weight and of exceptional strength, since the web is braced in every direction. The weight per square foot was 6 lb.

Erection

The first field operation was the placing of a metal cap on the masonry foundation wall. The cap was of 16-gage galvanized steel, turned down over the edge of the foundation for 2 in., and then bent at right angles 1 in. to receive the insulation and exterior siding. The entire structure, floors, and load-bearing walls were welded to this cap.

Architect's drawing, visualizing the completed frameless steel house.

It also holds the house on the foundation without the use of foundation bolts. Only a direct vertical lift of 2 in. could move the structure from the foundation, and the slightest twist binds the cap against the foundation and anchors the house more securely.

The lower floors were next welded in place. A line was scribed 2 in. back from the edge of the foundation, which marks the edge of the floor. This leaves a ledge on which the load-bearing walls rest. Two-inch gaps were left for interior load-bearing walls.

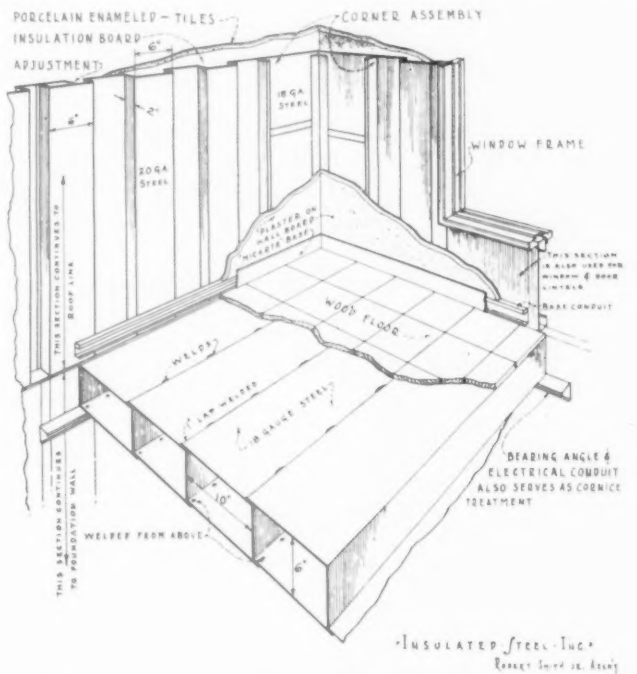
After the floors were welded together, the large wall sections were set in place, and welded both to the foundation cap and the floor. These wall sections are easily handled because of their light weight, and are quickly welded.

The same floor construction was employed for both the second floor and the roof. In erecting the two upper floors, a small angle of 16-gage steel, having legs 3 in. wide, with a ¼-in. lip turned in, was welded around each room at the ceiling line. This functioned as a temporary rest for the floor prior to welding it to the side walls, and served as a cat-walk for the workmen and a conduit to receive the electric wiring. Small braces were snapped in at frequent intervals and later removed when the floor had been welded to the walls. When the wiring was installed, a permanent cover was snapped in.

The erection of the second story and parapet walls was similar to the first. Only three men and one alternating current welding outfit were used on the erection work.

Exterior and Interior Finish

The exterior of the wall is heavily insulated against heat or cold. Celotex 1 in. in thickness was fastened to the protruding backs of the channels in the wall sheets.



Perspective drawing of welding assembly. The reinforced corner design adds great strength to the building, yet uses a minimum of material. The "Z" section flooring employs one-inch lap welds.

The exterior finish consists of porcelain-enamel shingles, eliminating house painting. These shingles are approximately 6 in. square, and are applied in strips 36 in. long. The Celotex and the shingles were fastened by a tempered, spirally-threaded nail, or drive screw. These nails easily penetrate the sheet metal walls, and can be driven more easily and rapidly in metal than in wood.

Gypsum wallboard, with two coats of plaster, was applied on the interior surface. In addition to the Micarta baseboards, the fireplace and mantel are of Micarta with inlaid oxidized-aluminum decoration. The master's bathroom is panelled in Micarta of contrasting colors. The other bath and the kitchen have linoleum walls. On future houses, both exterior and interior of walls will be factory finished.

The steel floors are coated with a layer of mastic. This acts as a sound deadener and also as an adhesive. On this is laid a laminated hardwood floor. The ceilings are of accoustical tile, cemented to the lower plane of the floor with mastic which serves not only as a decorative effect, but as a sound deadener. As the upper flat roof will also serve as a porch, a built-up asphalt roof covers the steel. Thin pieces of slates provide a walking surface. All doors and windows are of metal.

Welding

Electric welding is one of the contributing factors which has made possible the frameless steel house, according to Mills G. Clark, president of Insulated Steel, Inc., and the designer of the house.

The ordinary arc-welded steel building requires a large amount of welding on heavy structural members. In this frameless house, however, the welding consists of attaching formed sheets of thin-gage steel together by "tack" welds on lap and corner joints—a fabricating method lending itself to rapid construction. The welding interval is so short that the assembly operation on various panels appears to an observer very similar to nailing pieces of wood together.

This house is a marked advance toward the factory-built home. Though made entirely of sheet metal not much thicker than a dime, yet it possesses great strength and rigidity. Homes of almost any type of architecture, and apartment buildings, may be constructed by this new building method.

Mr. Clark erected this house as an experiment, in co-operation with the American Rolling Mill Company. The Westinghouse Electric & Manufacturing Company, Celotex Corporation, Libbey-Owens-Ford Glass Company, and a number of other firms also co-operated and are watching the results with keen interest.

A 207-Mile Welded Pipe Line

The Southern Fuel Company, of Los Angeles, Calif., has constructed a 26-in. steel pipe line from Kettleman Hills to Long Beach, Calif., a distance of 207 miles. The purpose of this pipe line is to provide a supply of natural gas for use by the Southern California Edison Company in its steam plant at Long Beach, and for distribution through distributing companies to Los Angeles and vicinity.

This line has a capacity of 130,000,000 cubic feet of gas per day. Three different thicknesses of steel were used in fabricating this pipe, $\frac{3}{8}$ of an inch at the Kettleman Hills end of the line, where the pressure was greatest, graduated down to $\frac{9}{32}$ of an inch, and finally $\frac{1}{4}$ of an inch on the lowest-pressure section of the line. The system is designed for an initial pressure of 400 lb. and a minimum pressure, at the extreme southern terminus, of 50 lb.

Western Pipe & Steel Company of California fabricated 76 miles of the pipe used on this line at its Los Angeles plant. The pipe was formed from flat plate. The plates were crimped at the edges in the usual manner and then formed on bending rolls, after which they were transferred to automatic arc welding machines where the 30-ft. longitudinal seams were welded with the automatic metallic-arc process. After this welding operation, pairs of 30-ft. sections were welded together into 60-ft. lengths and in this form were shipped to the field location where they were welded into a continuous line, cleaned, painted, wrapped and repainted.

Progress of Welded Ship Construction In Britain

Since the all-welded vessel *Fullagar* (now *Sheaf*) was launched at Birkenhead in 1920, but little actual progress has been made in the United Kingdom with the construction of ocean-going welded ships. The blame for this state of affairs cannot be put on the classification societies, for ten years ago Lloyd's Register of Shipping issued a set of regulations relating to the use of electric welding in the construction of ships, and their example was followed by other classification societies. All these rules show that the societies have been prepared to accept electric welding, subject to being satisfied as to the strength and quality of the work.

Recently, however, interest has been renewed in this method of construction, partly through reports of the extent to which it is being adopted in Germany and the United States and the economies in material attendant on its use, and it has also received a substantial stimulus from the action of the classification societies in permitting its wider application.

At the beginning of 1932 the British Corporation Register of Shipping and Aircraft, followed by Lloyd's Register and the Bureau Veritas, issued further provisional regulations on electric arc welding in shipbuilding, and these rules are confidently anticipated to induce ship owners and ship builders to give serious consideration to the extended use of the process. The regulations of the two British societies are closely similar, but those of the Bureau Veritas differ in many important particulars. British ship builders are agreed that there is a great scope for the employment of electric welding in the ship-building industry and that it is destined to play an important part in the future of the trade.

A.W.S. Reports to Be Put on Bargain Counter

Effective for one month beginning with this notice, the American Welding Society is offering a number of its reports at one-half their regular price. This is made necessary because of a reduction in storage space to effect economies. Among the reports offered at reduced prices are the following:

Structural Steel Research Report, 200 pages, covering five-year program involving testing of several thousand specimens and the co-operation of 40 fabricating shops and 30 testing laboratories. Special price, 50 cents.

Nomenclature, Definitions, and Symbols (covers all types of welding and applications). Special price, 25 cents.

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Steel sheets can now be had with a stainless-steel surface. The welding of stainless-clad sheets is much the same as of any other bi-metal, although the procedure employed depends upon the gage of the sheet

The Welding of Stainless-Clad Steel

By **S. L. Ingersoll**
Vice-President in Charge of Research, Ingersoll Steel & Disc Company

THE wide interest in clad steels has brought forth various questions as to their applications, their method of fabrication, and, of particular interest to the welding man, "How can they be welded?"

Stainless clad steel may be welded by ordinary gas or electric welding methods. The welding procedure has been thoroughly worked out with the leading gas and electric welding companies and they may be consulted as to procedure for special problems. Depending on the gage of the clad steel, these companies have developed successful methods for making lap, butt, V, and flange welds which assure a perfect weld embodying the stainless-steel characteristics at the stainless surface. Again, depending on the thickness of the sheet, the mild-steel side may have either a stainless weld or a low-carbon-steel weld, whichever proves more economical in production.

The thinner gages (from 16 to 10 gage) may be advantageously welded by making an ordinary butt weld, using a stainless-steel electrode which deposits a true stainless steel of the same formula as the stainless clad at the weld. In electric welding of thin plates, normal currents may be used, as would be the case if the entire thickness were of stainless steel. By holding the welding rod in an almost vertical position and welding from the stainless side, sufficient penetration is obtained through the soft steel and results in a perfect, homogenous stainless weld. If it is impossible to weld from the stainless side, the same stainless electrode may be used to affect an absolutely reliable welded junction by approaching from the soft-steel side and allowing a penetration or percolating effect to the stainless surface. In spite of the fact that the currents employed are critical, most of the modern electric welding equipment can produce these thinner plate welds with entire success.

If the stainless surface exceeds 10 gage, it is recommended that the edges of the plate be beveled to an angle not greater than 45 deg. each side, thus forming a total angle of not over 90 deg. at the butt joint. Either the soft steel or stainless side may be beveled, and the same procedure followed as is usual in the making of a butt weld. To reach the root of the bevel, a small gage rod (No. 12 gage) can first be applied, the slag removed, and the second application of a large rod applied immediately above this, effecting a fusion between the first deposit and the edges of the plate. This procedure goes on until the bevel is completely filled and the weld completed.

Where the plates are about ¼" thick or greater, a more economical weld may be made by changing to a soft-steel electrode after the first two stainless-steel layers have been placed, provided the mild steel was uppermost. The soft-steel rod will combine perfectly with the stainless rod at the root face of the bevel to effect a satisfactory, homogeneous weld. If the small end of the bevel is at the mild-steel surface, the above procedure would be reversed.

Fig. 1 illustrates a modification of the above process. Here the mild steel is beveled through the stainless clad and filled, using a mild-steel rod. Then a chiselled notch widens the stainless opening and a stainless rod

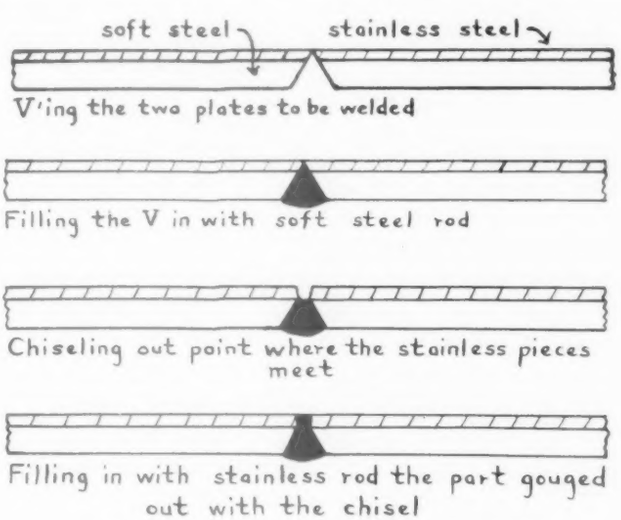

soft steel
stainless steel
V'ing the two plates to be welded
Filling the V in with soft steel rod
Chiseling out point where the stainless pieces meet
Filling in with stainless rod the part gouged out with the chisel

Fig. 1. Method of Welding Stainless Clad Steel.

completes the weld to preserve the continuity of the stainless surface. A standard butt weld shown in Fig. 2 does not show any evidence of the weld on the ground edge, other than the enlarged thickness at the weld.

This new stainless clad steel is the result of many years of experiment in an attempt to secure a perfect bond between a stainless steel and a mild steel. The need for such a combination metal arose from the necessarily high cost of the solid stainless steels, which excluded their use from many applications where a stainless surface was desirable, but, unfortunately, where the use of a solid stainless steel

was prohibitive for economic reasons. For several years it has been evident that a combination metal was to be the ultimate solution to the problem of bringing a lower-cost stainless metal to the industrial field.

Stainless clad steel is made by rolling finished sheets from a composite ingot. The stainless surfaces are polished before the mild steel is applied, which eliminates any possibility of scale, pit marks, slivers or roll marks appearing on the stainless surface during the rolling process. The process of combining the two metals in the ingot assures a complete and perfect welding throughout the entire surface of the sheets.

The process enables us to employ any one of many formulas for the stainless-steel surface, embraced in several license agreements which cover the various stainless alloys for which there are large tonnage potentialities. It further assures not only a complete uniformity of thickness of the stainless clad and the mild-steel base, but also

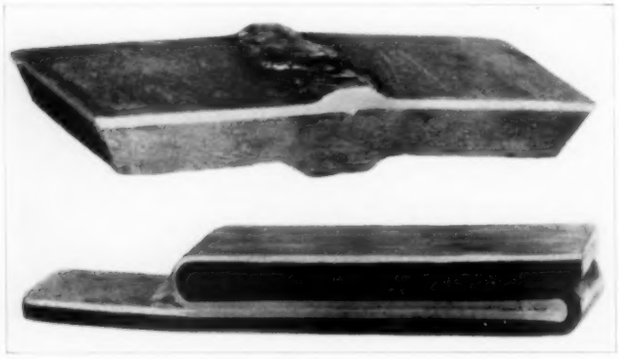


Fig. 2 (Top). Standard Butt Weld of Stainless Clad Steel.
Fig. 3 (Bottom). Sharp Bends in Bi-Metallic Strip Do Not Affect Bond Between Metals.

allows us to vary the thickness of either to produce a finished clad sheet or plate of any commercially practicable size. In other words, there is a very wide latitude in its manufacture, which will permit the production of the stainless clad metal to satisfy the requirements of a wide range of commercial applications.

There are several aspects in the fabrication of this stainless clad steel which merit the attention of the user and fabricator. With its usual small percentage of stainless surface, the sheets or plates may be deep drawn, stamped, formed, welded, and highly polished. It offers possibilities in the form of tubes and pipes, bars and shapes, as well as sheets. Short-radius bends (see Fig. 3) have no effect on the bond between the stainless-steel surface and the mild-steel back.

This stainless clad steel does not require any heavier equipment for fabricating than does a mild steel of the same thickness, as it usually has a relatively small percentage of the harder stainless surface. This feature is important to the fabricator who can employ present equipment and thus avoid the large capital expense necessary in changing from a soft steel to a solid stainless product.

This clad steel costs from 40% to 50% less than solid metals of like characteristics, which brings it within the reach of countless applications where the stainless-steel surface has been desirable, but where the cost of the solid metals has made their use uneconomical. The fact that the process of manufacture lends itself to large tonnage production indicates that the major uses will be in the mining, process, food, and metal-working industries.

This clad metal has been used with complete success in several of the process industries in cooking vessels, vats and tanks. Likewise, the automotive industry has employed it for hardware, metal wheels, and other applications where high polish and resistance to atmospheric corrosion have been dominating factors.

In applications where some degree of protection or polish is desired on the mild-steel side, as well as that furnished by the stainless surface, the carbon-steel side may be given a low-temperature enamel coating, or it may be protected by aluminum, asphaltic, or other resistant paints, or plated by parkerizing, the Udilyte process, or other means.

Considerable research work which has been carried on in spiral welding of pipe with the stainless surface on either the interior or the exterior of the pipe gives complete assurance of a perfect weld, and the stainless portion of the weld has the same corrosion resisting properties as the stainless surface of the pipe. For pipe and plate work the stainless layer may comprise from 5% to 50% of the total thickness of the metal, depending upon the pressures and degree of corrosion resistance demanded.

Iowa State College Announces Fifth Welding Conference

The dates of January 18th to 20th have been selected for the fifth welding conference to be held at Iowa State College, Ames, Iowa, according to D. C. Faber, director engineering extension service. A feature of the program will be lectures and demonstrations on the application of qualification tests to welders.

Frank P. McKibben Awarded Miller Medal

At the annual dinner of the American Welding Society held in Buffalo, N. Y., on the evening of October 5th, the annual award of the Samuel Wylie Miller Medal was made to Frank P. McKibben, president of the Society and internationally known authority on welded structures.

Mr. McKibben has had a wide and varied experience in the fields of teaching and of structural design. From 1894 to 1907 he was on the faculty of the Massachusetts Institute of Technology, and then for twelve years he was professor of civil engineering at Lehigh University, followed by a similar position at Union College until 1926, when he went into consulting practice. During these years he was connected in a consulting capacity with several engineering firms and public-utility commissions.

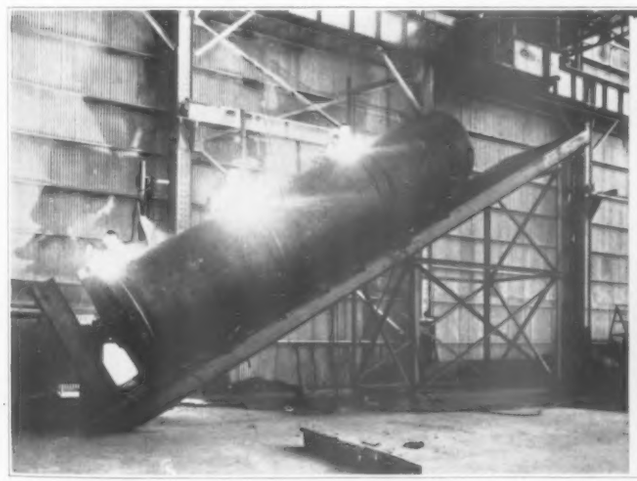
In 1922, Mr. McKibben, with Ernest Humphreys, made the first tests on fillet welds in longitudinal shear. Since 1927 he has been connected with the welding of twelve structures, including the office building of the Dallas Power & Light Company, the power plant of the Hotels Chalfonte and Haddon Hall in Atlantic City, the office building of the Edison Electric Illuminating Company in Boston, and shops of the General Electric Company in Bridgeport and West Philadelphia. For three years (1929-31) he was engaged by the General Electric Company to call on cities all over the country and make recommendations regarding building codes. At present he is connected with the consulting engineering firm of Carson & Carson, in Philadelphia. Mr. McKibben when at home is on a farm at Black Gap, Pa.

First All-Welded Penstock in America

By W. E. Archer

ONE of the major welding jobs for California in 1932 has reached completion at this time in the fabrication and installation of a large penstock for the city of Los Angeles. To this city, according to available records of this kind of construction, will go the credit for the installation of the first power penstock ever constructed and installed entirely by welding in this country. This penstock was installed just above the city's water-power plant No. 2 in the San Francisquito Canyon, located in the rough Tehatchapi Mountains, a distance of some fifty miles from Los Angeles.

Shop fabrication of the pipe, as well as field installation of the penstock, was done entirely by electric arc welding, employing for the major portion a special automatic shielded-arc process developed by the Consolidated Steel Corporation, of Los Angeles, which company was awarded the contract for the fabrication of the pipe. The field work of assembling, tieing together the pipe sections, and complete installation, was done by the power and light department of the city of Los Angeles, who employed the same process of welding, type of rod, and general procedure as were used in the shop welding, except that hand welding was of necessity used in the field. Considerable difficulty was encountered in the field work of this project by reason of the steep incline of the mountainside up which the penstock was laid for the greater portion of its length.



Welding Three Butt Straps Simultaneously on a 30-Ft. Section.

Section With Bend, Showing Head Welded on One End Preparatory to Making a Hydraulic Test.

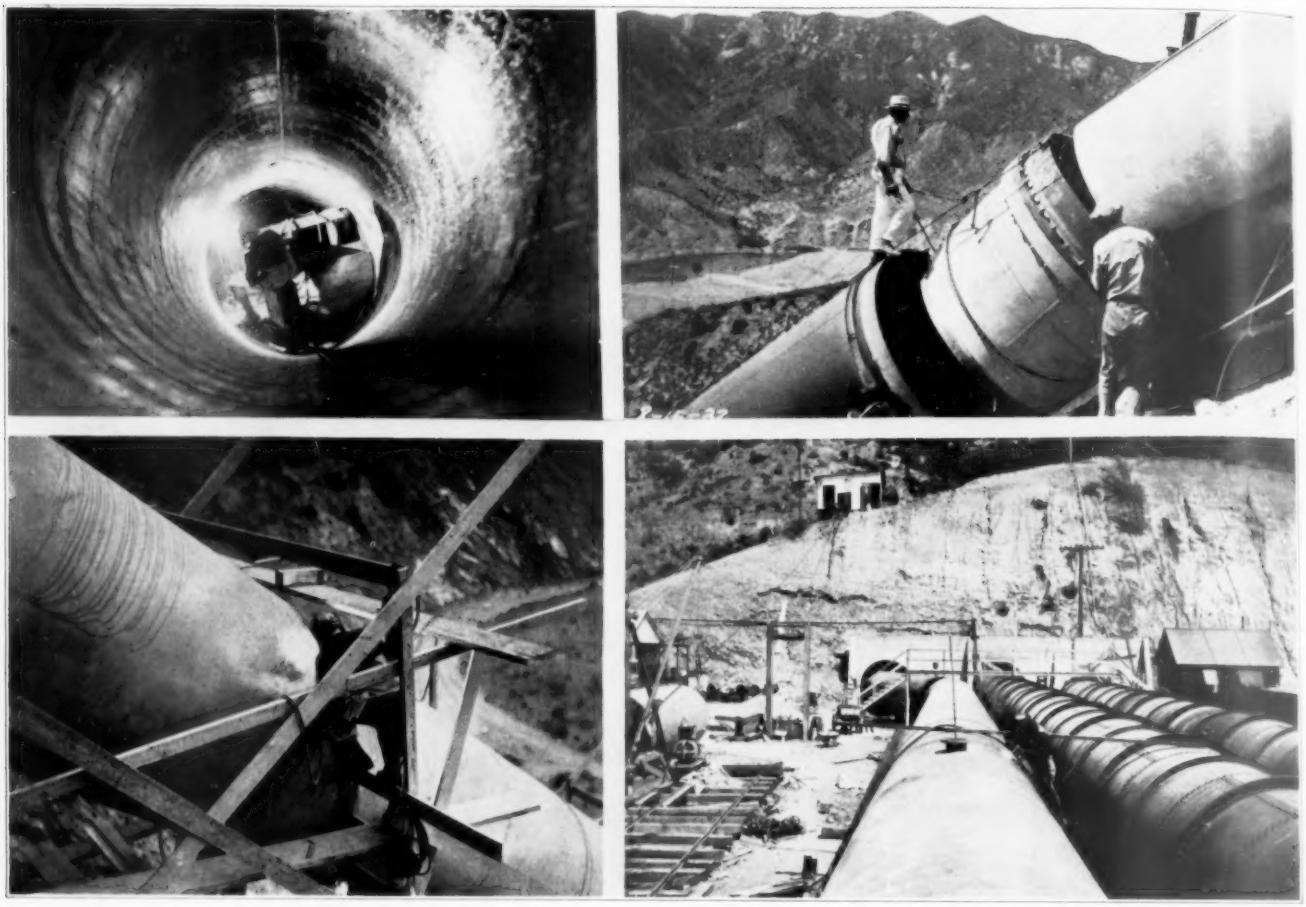
Shop Welding

The penstock ranges in diameter from 84 in. at the top, or point of intake, to 72 in. at the base, where it enters the power house. The total length of the penstock is approximately 1,400 ft. The wall thickness of the pipe graduates by a sixteenth of an inch, according to the diameter of the pipe, from 3/8-in. for the 84-in. pipe to 7/8-in. for the 72-in. pipe. The pipe sections as delivered in the field were 30 ft. long and were fabricated of three 10-ft. pieces of shell plate. In assembling these shell plates into the 30-foot sections, butt joints were employed, these being covered with a butt strap 6 in. in width and of the same thickness as the pipe, and being formed to fit around the pipe. For the welding of all longitudinal seams as well as the inside circumferential seams on the straight sections, the automatic electric arc process was used. The butt strap was welded at one side prior to the operation of making the inside circumferential weld, and thus the butt strap formed an excellent back-up ring for the butt weld, which was made from the inside of the pipe. Welding the butt straps, as well as all the elbow joints and joints forming lesser angles, was accomplished by hand, both inside and out, since this was the most practicable method. Multiple pass welds were required on all seams by reason of the heavy plate.

Prior to the shipment of these 30-ft. sections, a butt strap was welded on one end of each section, thus reducing the amount of work required in the field assembly, in that each joint was ready for fitting into the next one, and one field weld was eliminated at each joint. All joints were, by trial, made to fit perfectly together in the shop before shipment was made, and were numbered consecutively to assure accuracy and uniformity in the field assembly. A 2-deg. entering angle was machined in each butt strap and joint end to facilitate assembly. All edges were beveled to the proper angle according to the thickness of the plate, for the most effective results in welding. This beveling was done in a 30-foot planer before rolling the plate. The average speed attained in the process of the automatic arc welding on this job ranged from 30 to 40 ft. per hour.

Testing

All 30-foot sections made of 1/2-in. and heavier plate (comprising about 500 ft. of the entire penstock) were stress relieved at approximately 1150 deg. F. in the steel company's furnace. Weld test coupons were provided on each 10-ft. shell similar to the requirements for pressure-vessel welding, and were tested for tensile strength and ductility, in accordance with the city's specifications and requirements on fabrication. On completion, all joints were given a hydraulic test to double the working pressure of the penstock. The testing of the regular straight sections was done in a testing machine within the



(Top) Laying an Inside Bead Along Circumferential Seam.
(Bottom) Making a Position Weld on a 42-Degree Slope.

(Top) Setting a Welded Expansion Joint in Place Preparatory to Welding It Into Position.
(Bottom) Looking Uphill Toward Tunnel Entrance, With Welded Penstock on Left.

shop, having specially fitting heads which were easily secured in place at each end of the pipe sections to make a water-tight head. The elbow joints, together with all joints with angles which because of their irregular ends could not be tested in the special machine, were tested by welding a head in each end and pumping the joint full of water and bringing the pressure to the required point.

Field Welding

On account of the extreme heat in the summer, welding operations on the job had to be carried on during the cool part of the evenings and at night, except for tacking, short finishing beads and other of the minor operations. During most of the daylight hours the sun made welding, both inside and outside the pipe, almost unbearable. Therefore, working hours from four in the afternoon to eight in the morning were adopted for welding, with two crews being employed, one working up to midnight and the other from midnight on.

Welding rods ranging in size from 5/32 to 3/8 in. were used, according to the pass or bead being run, and larger electrodes were used on the finishing beads. The size of welding rods also varied according to the thickness of the pipe wall. About one hour was the average time required to make one complete circumferential bead around the pipe. From eight beads on the lighter-weight pipe to 32 beads on the pipe with the heaviest walls, were the

DATA ON FIELD WELDING OF PENSTOCK

(From paper by Clayton M. Allen, read before the Los Angeles Section, American Welding Society, September 22, 1932)

	Time	Electrode	Energy	Beads	Electrode per hr.
Average of 33 joints on 84-in.-diameter sections, formed of 3/8-in. steel, welded on angles from 0 to 40 degrees with the horizontal—					
Butt Weld	12.8 hr.	20.7 lb.	48.0 kw.-hr.	10.3	1.62 lb.
Lap Weld	11.0 hr.	18.9 lb.	46.2 kw.-hr.	8.4	1.73 lb.
Average of 17 joints on 81-in., 1/8-in. to 72-in., 7/8-in. sections, welded on angles from 20 to 42 degrees with the horizontal—					
Butt Weld	28.2 hr.	44.0 lb.	106 kw.-hr.	24.3	1.56 lb.
Lap Weld	19.1 hr.	30.5 lb.	69 kw.-hr.	16.7	1.60 lb.
Average of entire 50 welded joints—					
Butt and Lap Welds	31.8 hr.	50.8 lb.	121.5 kw.-hr.		1.59 lb.

NOTE: An average of 3 in., or 21.4% of each 14-in. electrode was waste.

requirements on the inside joints. In the field, the outside welds at the butt straps required from 6 to 20 passes, depending upon the thickness of the pipe wall. From this, one can gain some idea of the great number of welding hours required to finish even the field work alone. Seven welders comprised each crew on most of this work. Lincoln welding generators were used in the field.

In laying out the sections for welding in the field, a space of about 5/32 in. was left between adjoining sections. Six tack welds from 6 to 8 in. long were made at each joint. These were built up gradually and evenly in much the same way as the main beads, the operator passing from one tack weld to another, adding a bead at a time to each, but leaving the last few beads to be applied at the time the completing weld was made. Penetration into the butt strap beneath was made as complete as possible.

For 800 ft., just before entering the power house, the penstock lies on a mountain side having a grade of 50%, which made the handling of materials somewhat difficult and dangerous. Supplies and materials were transported up the steep incline on a cable tramway, as seen at the left in the view on the front cover of this issue. The penstock is supported by concrete piers set several feet in the ground under each joint.

This all-welded penstock will carry approximately 333 second-feet of water, and will drive a generator which will deliver 20,500 hp. of electric energy.

The shop welding work on this project was under the direction of J. B. McClellan, superintendent of production for the Consolidated Steel Corporation, assisted by Wayne A. Howard, research engineer.

R. R. Robertson, engineer for the city of Los Angeles, was in complete charge of the entire project, while the field welding of the penstock was under the supervision of C. M. Allen, junior electrical engineer.

Welded Piping for High-Pressure and High-Temperature Service

(From paper by F. W. Martin given at 32nd annual convention of International Acetylene Association, Chicago, Ill., November 11-13, 1931.)

Steam pipe lines as installed in modern power stations involve great hazards and must operate under very severe conditions. Steam pressures of 450 and 650 lb. are common, with corresponding temperatures of 700° to 750° F. Steam pressures of 1200 to 1400 lb. are in use in many stations with temperatures of 750° to 850° F. The use of these latter pressures and temperatures is rapidly increasing.

This service is somewhat different from oil-refinery practice in that the piping is usually in a more restricted space and is almost always larger in size. Steam mains 12 to 16 in. in diameter are common practice, while in oil-refinery work pipe lines are not usually much over 6 in. in diameter. The wall thickness of a 14-in. steam pipe to carry steam at 1200 to 1500 lb. pressure is nearly 1⅛ in. Due to the restricted space in which this must be installed, the expansion and contraction with changes in temperature become a considerable factor and the resulting stresses set up in the pipe may be 10,000 or 12,000 lb. per sq. in., as computed, and probably even higher in actual practice. Because of these extraordinary conditions, only the very highest type of welded work can be countenanced. A failure in a large steam line might cause not only property damage amounting to possibly a million dollars, but might also involve the loss of several lives.

To date most of the steam pipe welding in power plants has been done by the oxyacetylene process, although some low-pressure jobs (not over 250 lb. steam pressure) have been done by the electric-arc method. Oxyacetylene is apparently preferred by most of the large piping fabricators for this work because they feel that a more ductile weld material is obtained than in the ordinary electric-arc joint. In the case of shop welding of such equipment as drums, where it is possible to stress-relieve and to roll the work to the welder so that he is always working on a horizontal surface, the electric arc, either plain or with various shielding modifications such as is produced by heavily coated rods, is used very successfully, and probably to a greater extent than the oxyacetylene process at the present time.

Several qualification tests of varying degrees of complexity have been proposed by various authors, all of which are probably satisfactory for some particular welding operation. However, for high-pressure steam pipe work, only the very highest grade of welding can be permitted because of the extreme hazards and the very arduous service which such joints must endure. The author, therefore, feels that the qualification test for welders for this type of work cannot be too stringent. The first requisite for a welder is several good refences as to be his moral character, experience, habits, and ability. These supplemented by a personal interview are about all

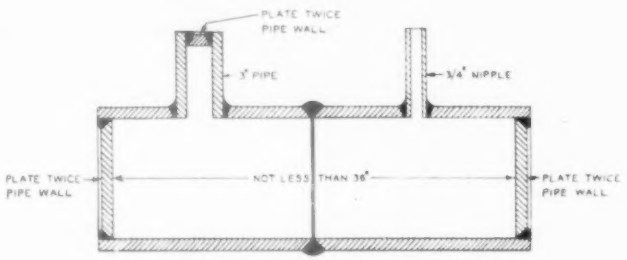


Fig. 1. Qualification Header for New Welders.

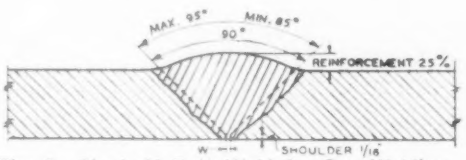


Fig. 2. Single-V Butt Weld for Gas Welding.

that can be done along the line of character analysis. The next requisite is an adequate test of his welding ability.

Fig. 1 shows a qualification header used, with slight modifications, by the Consolidated Gas & Electric Company, the Detroit Edison Company and others to test welders for their steam pipe line work.

The butt weld joining the two pieces of pipe is a position weld; the welder moving around the joint, which is held stationary during the work. One of the closed end welds is made in a horizontal overhead position, and the other in the normal horizontal position. These welds are all made without moving the work. The remaining three welds can be made in the position most convenient to the welder.

After the header is cool it is subjected to a hydrostatic test to destruction. The welds must not fail below the hydrostatic pressure specified for the pipe used. If any of the welds show slight pin hole leaks the pressure may be released and the welder may repair these once. Failure to hold a second time rejects the welder.

All pipe joints which are not subjected to bending stresses shall be single V butt welds with 25 per cent reinforcement, as shown in Fig. 2.

All pipe joints which may receive bending stresses shall be single V butt welds with the weld metal flush with outside surface of pipe, and shall in addition be reinforced with a close-fitting sleeve arc welded at the ends to the pipe as shown in Fig. 3.

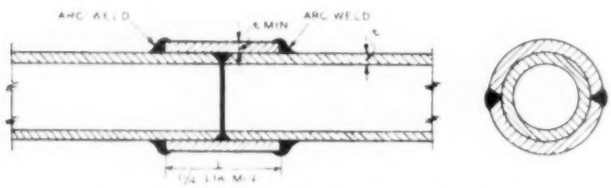


Fig. 3. Butt Weld With Welded Split Sleeve.

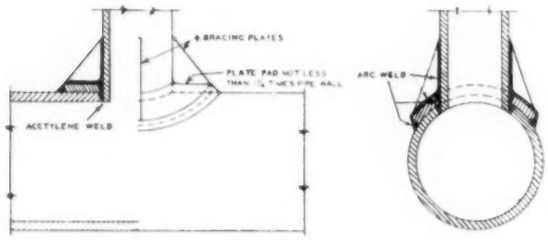


Fig. 4. Details of Welded Nozzle Connection.

Small nozzles shall be accurately fitted to the pipe and tack welded, after which they shall be welded with single fillet welds penetrating to the inner surface of the pipe. In the case of nozzles of pipe one-half the diameter of the principal pipe or larger, the weld shall be reinforced by a close-fitting pad completely surrounding the nozzle and welded to the nozzle and the pipe. This will compensate for the metal removed in cutting the hole for the nozzle. See Fig. 4.

Butt joints heavier than $\frac{7}{32}$ in. shall be beveled as shown in Fig. 2. Beveling shall preferably be by machine, but may be done with the torch if the surfaces are thoroughly cleaned from scale and oxidation afterward. Butt welds in steel pipe shall have the ends spaced in accordance with accepted standards before tack welding. Spacing and tacking should be such that the abutting edges shall at no time come in contact before welding.

The sizes of tack welds shall in no case be greater than one-half the thickness of the thinner material joined, so as to insure weld continuity. If larger, they shall be melted or chipped out prior to or during welding.

After completing a welded joint the welder shall stamp it with a number or mark to identify it as his work. This last is an important provision, as it identifies beyond doubt the maker of every weld. In case of failure to pass inspection later or failure in service, the weld can be traced back to the mechanic. Knowledge that this is the case will exert a strong influence on the welder to exercise care and not turn out defective work.

No globules of weld metal shall project within the pipe so as seriously to restrict its area, or cause danger of loosening and falling into the pipe.

A qualified inspector should be continually watching the work during its progress. On welding work done in the shop, one inspector can probably supervise and watch the work of 15 to 18 welders. On field work one inspector cannot watch more than about 10 men. This inspector should have full authority to stop any welder whenever in his judgment the work is not being done satisfactorily and require that the unsatisfactory work be cut out and done over. During the progress of the welding the inspector should from time to time select a weld from the work of each welder; these welds to represent approximately 2 per cent of the work of each welder. From these welds coupons not less than the pipe thickness in width should be cut. Coupons should be etched and examined as specified under the qualification test for welders. If satisfactory, the coupons should be pulled in tension and should show a strength, including the 25 per cent reinforcement, not less than the tensile strength of the base metal. In the case of field welds made in position, a coupon from the under side of the weld should show not less than 75 per cent of the tensile strength of the base metal. Failure of a coupon to meet these tests would be cause for rejection of the weld tested and call for a careful inspection of all work by the same welder since his last test and a check coupon from another weld by the same welder. The failure of a second coupon from another weld should be cause for the suspension of the welder until he could show proof that his work fully met the requirements for uniformly satisfactory welds.

In addition to this inspection of the individual welds, all the piping after welding should be subjected to a hydrostatic pressure of one and one-half times the working pressure, and while under pressure the weld should be struck with a two to six-pound hammer with blows hard enough to jar the welds without indenting the material. All pin-hole leaks should be repaired by welding, but special care must be taken to prevent local stress concentration due to heating and cooling. A general sweating of any weld would be cause for its rejection and complete removal and rewelding.

In the case of shop welding, non-destructive tests such as the X-ray are practical and could very well be used in addition to the coupon and visual tests specified above. In case the X-ray is used this would give a permanent record of inspection of all shop welds. The objection to X-ray has been raised that it is expensive and is not a 100 per cent test, showing up only one type of fault. This is true. On the other hand, neither are the tension tests or the etching and visual tests 100 per cent. Each of these tests checks a certain type of fault.

In the present state of the art, with the small amount of knowledge of welds and welding, and the natural distrust felt by engineers of a new development, the more tests to which welding can be subjected, the better. It is only by careful work, elaborate testing, and long experience that the natural distrust of engineers for a new development can be overcome, and welding placed in the position of an accepted method for joining high pressure and temperature steam piping in power plants. The writer feels that this time is rapidly approaching. The welding fraternity must not, however, precipitate ill considered applications with consequent disastrous failure.

Spot Welding the Stainless Steels

By V. W. Whitmer
Metallurgist, Republic Steel Corporation

STAINLESS steels are particularly well adapted to spot welding owing to their clean surface, freedom from any oxide or scale, and because of the absence of any coating such as zinc or lead, as on galvanized or terne plate stock.

Spot welding, in principle, is nothing more than holding two sheets in close contact between two copper electrodes about an inch or so in diameter with the contact ends tapered to about ⅛ in. in diameter, and passing a current low in voltage, but high in amperage through the circuit for a short period. Fusion immediately takes place between the two sheets, while the excess heat is rapidly carried away from the outside surfaces by the water-cooled electrodes.

The area of the electrode points should be maintained as near constant as possible. Any increase in area will tend to reduce the heat per unit area, resulting in an improperly or poorly fused joint. A decrease in area will increase the unit heat and will usually burn a hole entirely or partly through the sheet to be welded, other factors remaining constant.

The pressure exerted by the eloctrodes also affects the quality of the weld. Too much pressure will reduce the resistance of the joint and hence tend to decrease the heat generated. The pressure generally determines the amount of up-set displacement directly following the fusing period, producing an indentation on each side of the sheets welded.

In addition to these variables, the time of current flow is of great importance. Too long a period gives the same result as too much heat, and too short a contact will produce no weld.

Stainless steel, such as Enduro, in general will require less heat than the same gage in common steel, due to its lower heat conductivity (tending to concentrate it in one spot), its lower melting point, and better contact due to a scale-free surface. Consequently, if an operator is producing good work on, say 20-gage black steel, he could, in general, change to the same gage stainless by either dropping the rotary control switch one point or reducing the time slightly, or both. More definite instructions cannot be given, but the exact procedure must be worked out individually, balancing one variable against the other until the desired result is obtained.

If both electrodes are of the same diameter, a depression will occur on both sides which, while not serious on the pickle finishes, may be objectionable on the polished surfaces. This effect can be reduced by using a copper block about ½ in. thick and 2 in. square between the electrode and polished side, thus putting the major depression on the lower side. An aluminum block ⅛ to ¼ in. works even better, but, due to its lower melting point, will tend to pit if a slight arc is drawn. This procedure will reduce the depression, but will not eliminate it entirely, as it is due to shrinkage of the molten metal in the center and, hence, pulls from both surfaces. The indentation remaining, if the work is to be polished, will have to be ground out with a cotton wheel set up with glue and abrasive (about 80 grit or finer).

When welding polished stainless steel, it is advisable to place the welds at the least conspicuous positions, as often it is difficult to refinish the welds and have the same color if the whole piece is not refinished. This depends, however, to a great extent, upon the finish of the sheets.

Spot welding, like any other type of welding requiring high temperature, will form an oxide on the surface which will be blue in color. If this is exposed to the weather or moist conditions, it will slowly change to a brown color resembling rust. This, however, is only a surface condition, affecting the original oxide only. If such welds are to be exposed to the atmosphere, they should be cleaned either with acid as in pickling in the case of No. 1 finish sheet, or ground and polished if No. 4 or higher finishes are employed. In the ground and polished state, spot welds are just as resistant to salt spray as the original metal.

Tentative Program for Annual Meeting of I. A. A.

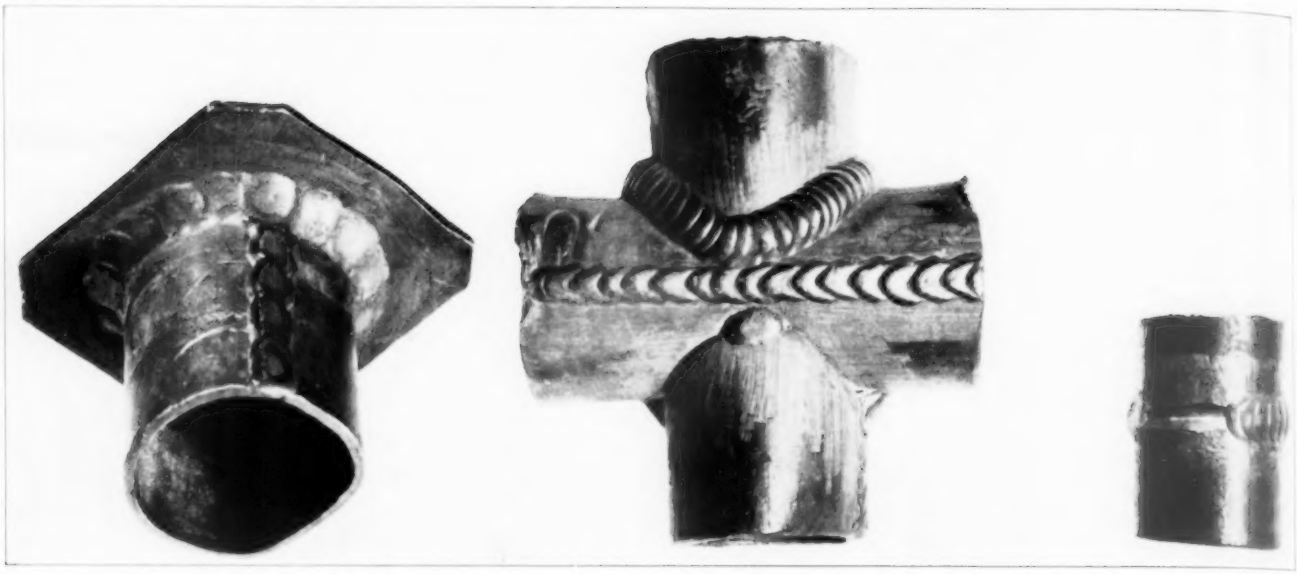
Oxy-acetylene welding in the fabrication and repair of watercraft, aircraft, buses and motor trucks, and for the repair of rail ends, is to be considered in a series of papers tentatively scheduled for the Annual Convention of the International Acetylene Association to be held November 16th to 18th, at the Penn Athletic Club, Philadelphia, Pa. Sessions are also scheduled on welded piping, welding in the steel industry, welding of alloys and non-ferrous metals, and oxy-acetylene cutting. A night session is to include papers and demonstrations on welding and the training of welders, which will be of special interest to those in attendance at the Convention.

Los Angeles Section of A. W. S. Hears Paper on Welded Penstock

The first fall meeting of the Los Angeles Section of the American Welding Society was held on September 22nd at the Mona Lisa Restaurant and was preceded by a dinner. The meeting was well attended. Clayton M. Allen, Junior Electrical Engineer of the Bureau of Power & Light, City of Los Angeles, gave an interesting paper describing the installation by that city of an arc-welded penstock. Mr. Allen had complete charge of the field welding of this penstock and gave a detailed description of the entire job. Illustrations of the shop and field progress of the work added considerable interest to the paper. A description of this penstock appears elsewhere in this issue of THE WELDING ENGINEER.

Engineers' Week at Century of Progress

The week beginning June 25th will be set aside as Engineers' Week at A Century of Progress (World's Fair), to be held in Chicago next year. Many notable engineers will be present, and it is expected that all the engineering societies will participate in technical meetings and other activities to be held during the week. The management of the Chicago Power Show has announced that that exposition will be held during the same week.



Lead Pipe Made From Sheet Lead by Welding With Flange Attached by Welding. Often Used Where Pipe Penetrates Lead Tank Linings.

Cross in Lead Pipe, Partly Welded. Note in This View and in Illustration on Right Where Pipe Has Been Scraped Clean With Shave-Hook.

Ordinary Welded Joint in Lead Pipe, Incomplete, Showing Beveled Ends.

Lead Welding—

Procedure and Applications

By Robert L. Zigfield
Lead Industries Association

From a paper presented before the Fall Meeting of the American Welding Society, held in Buffalo, N. Y., October 3-6, 1932

AUTOGENOUS welding of lead, known to the trade as lead burning, is a process which has been developed through many centuries of use and grew to really large proportions with the general availability of modern commercial gases such as oxygen, hydrogen, acetylene, and calorene under pressure in cylinders. Today it is becoming increasingly important because the fields in which it is most generally applied are growing. Despite this there has been little written on the subject, probably because as a trade it was largely handed down from father to son, with instruction gained by personal contact and knowledge by personal experience.

The war, which caused great expansion of munitions and other chemical plants, caused lead burning to be more widely taught because of the dire need for lead burners in these plants, and it is now taught in some trade schools.

The oxy-hydrogen method of lead burning played such an important part in the war. Air-acetylene flames made their appearance after the war, but were limited to flat work and never became of great importance. However, they gave rise to the oxyacetylene method which is of considerable importance now.

Although there is some claim that oxy-hydrogen flames cause greater volatilization of lead than other types of flames, and that the hotter flames of other gases do better work, the vast majority of expert lead burners prefer oxy-hydrogen and claim that they can use it with greater success. It is used with mixtures varying from 4 parts of hydrogen and 1 of oxygen to equal parts of each on heavy work.

Lead burning is a true autogenous welding process, differing from the welding of other metals in that the melting point of lead is low (621° F. and 327° C.). This means that the operation is considerably more delicate than other welding because care must be taken not to burn through the lead. Very small torches with extremely fine tips are used because a very hot flame is not necessary. To permit rapid manipulation of the torch, lead burners usually separate the tip from the mixing valves by a length of hose. Mixing valves can then be set down and only the tip manipulated.

Lead joints should be made in a horizontal position and lapped whenever possible. Laps of ½ in. to 1 in. are generally used. The lead is scraped clean with a shave-hook along the edges and back from the edges about an inch on both sides. This removes dirt and the coating of oxide that always forms on the surface of

lead. Cleaning is particularly important in repair work. After the edges are cleaned and in position it is well to tap the upper sheet lightly with a wooden mallet to assure intimate contact between the sheets. Using a filler bar, the seam is then welded. Very light lead does not require a bar, but the weights generally used commercially do.

Position of Welding Flame

The flame is held approximately at right angles to the work, with the lead at about the tip of the inner cone. The two lead surfaces and the bar are brought just to the fusion point simultaneously and then the flame is rapidly flicked away by a quick movement of the wrist. This allows the lead to fuse together in a homogeneous mass, but prevents excessive melting. As this joint solidifies, flame and bar are applied at an adjacent point and the operation repeated until the entire seam is complete. When finished, welded seams in lead have a typical herringbone appearance that is as regular as though done mechanically, if the work is good.

Butt welds are made in about the same way, the sheets being placed abutting and tacked in position with the flame. Ordinary weights and heavy sheets are beveled along the edge so that they make an angle of about 30 deg. with each other.

Horizontal seams on vertical surfaces are made by lapping the lower sheet over the upper, the edge of the lower sheet thus preventing the melted lead from running away.

Vertical Seams

Vertical seams are different in procedure. No filler bar is used and seams must be lapped, except in rare instances when butt welds may be made with the aid of a mold on handles manipulated by a helper. The lead is prepared in the same way as for horizontal seams but often has to be held in position by wooden forms while burning progresses. Welding starts at the bottom, the flame being applied to the top sheet until its edge is molten. This molten lead is guided by the flame down

Welding a Flat Seam in Sheet Lead.

onto the under sheet and fused with it, the flame being flicked away before the under sheet is burned through. A shave-hook held just below the working point may help to cool the lead in place. Vertical seams in lead have the appearance of a rope when completed. Even smaller tips are used on vertical seams than on horizontal seams.

Overhead seams should be avoided. They can be made only by especially skilled workmen and can never be made as strong as flat or vertical seams. When they must be made they are lapped and made without filler bar.

On all lead burning on which filler bars are used, the bar should have exactly the same composition as the lead; that is, if the sheets are chemical lead, the burning bar should be chemical lead; if antimonial lead containing 6% antimony, the bar should also contain 6% antimony. Crawlproof lead, which is chemical lead reinforced with bars of antimonial lead imbedded in it, is welded with the aid of a chemical-lead filler bar, the weld being built up a little higher than usual to assure sufficient thickness of chemical lead over the reinforcing bars.

Lead Welding is being applied to

- **Lead-lined tanks and vats**
- **Lead tubing, pipe, and fittings**
- **All-lead pumps, valves, funnels, carboys, etc.**
- **Linings for X-ray rooms, swimming pools, conservatories, fountains, etc.**
- **Anti-vibration pads**
- **Storage batteries (both production and repair)**
- **Ornamental lead work**

Leadworkers have several commercial grades of lead at their disposal and it is well to know the properties of each so that the correct grade may be selected for a given job. Most flexible is common lead (desilverized or soft Missouri) but it is also the weakest. It should be used where easy bending and working is at a premium. Chemical lead, which derives its name from its wide use in the chemical industries, is stronger, slightly less flexible, and more resistant to corrosion than common lead. It differs from common lead in that it contains larger amounts of copper—0.4% to 0.08%. Antimonial lead, whose antimony content may run from 1% to 13% and is generally in the neighborhood of 6% to 7%, has nearly double the strength and is much more stiff and rigid than either of the other grades. As a rule it is not quite as resistant to corrosion as chemical lead; but in some cases, as when it is in contact with salt water, it seems to be more resistant. Crawl-proof lead is still another possibility where both strength and corrosion resistance are important.

Welding Pipe

Welding of lead pipe is done the same as butt welds in sheet lead, and the joint is made on the flat. When it is impossible to do this or to get at the under side of the pipe, it may be slit open on top, back from the ends and the upper walls of the pipe bent back. The lower half of the weld can then be made from the inside, the upper walls bent back into place, and the top of the joint and the slits burned from the outside. Pipe joints may also be welded by flanging one end of the pipe and fitting the other end into the flare.

It may be necessary, in working with heavy lead, to burn over a seam several times to build it up to the proper thickness and assure a strong joint. Welds should be

built up a little higher than the adjacent metal but it should be remembered that beyond a certain point adding lead does no good. In architectural or other work where seams must be as invisible as possible, they may be scraped down flush with the lead surfaces after the seam has been finished.

Filler bars may be made by casting lead into regular molds for the purpose or using a piece of angle iron for the mold. A bar about $\frac{3}{8}$ in. in diameter is generally satisfactory for most work, on which sheet lead weighs from 6 to 10 lb. per sq. ft. ($\frac{3}{32}$ to $\frac{5}{32}$ in. thick). About 1 ft. of bar is then required per foot of seam.

It can be seen from this brief description of the mechanics of lead welding that it should not be difficult for a workman to master its fundamentals in comparatively short order. In fact, in two weeks the average man can be taught to do a fair job. But because of the delicacy of the operation and because the nature of the uses of lead welding demand a perfect job the first time, it is not easy, except after continued practice and experience, for a workman to produce flawless work rapidly.

Welded Lead Joints Resist Corrosion

Perhaps the largest field of application of lead welding is in the industries producing and consuming chemicals. Chances are that this application will continue to grow at a rapid rate because almost all modern development is dependent upon chemicals in one way or another. Many of these chemicals are highly corrosive to ordinary materials of construction, yet lead admirably resists corrosion by many of the most common. A few, in contact with which lead is commercially used, are sulphuric, phosphoric and hydrofluoric acids, common salt solutions, zinc chloride and ammonium sulphate. The extent to which these substances are used in industry gives some idea of the extent to which lead is used in handling them, and welded joints are used almost exclusively because solder would be attacked and destroyed, and also because solder melts at lower temperatures than lead and would fail where processes required even small amounts of heat.

Storage and process tank linings are therefore often lead with welded seams. These linings may be loose linings, simply hung from the top of the tanks. They may be supported linings, with steel strips, running either horizontally or vertically, fastened to the tank shell through the lead and thus supporting it. Strips of lead are then placed over the steel strips and burned to the lead lining so that nothing but lead is exposed. Or still another possibility is homogeneous linings where the lead is actually bonded to the steel. This bonding may also be done by burning. The steel is first carefully cleaned, and fluxed with zinc chloride solution. Lead is then flowed onto the steel with the aid of a lead burners' torch, and becomes firmly attached to the steel.

Of course, much chemical equipment is entirely fabricated of lead, particularly antimonial or hard lead, and here again joints, when necessary, are burned. This would include not only pumps and valves, but also funnels, carboys and many other pieces of equipment. Heating coils are very frequently used in chemical tanks such as plating tanks. They may be made of coiled lead pipe either with pieces of lead burned between each turn as spacers, or with lead pipe legs running from top to bottom of the coil with notches cut out for each turn, and burned in place. Even floors in chemical plants are sometimes entirely covered with lead to prevent sparking and attack by corrosives, and seams are welded.

Not Affected by Salt Spray or Brine

When lead pipe is used to transport corrosives, joints in it are also burned. Here is a big field because lead pipe is so generally used to handle salt water, an extremely common corrosive. This is not only true in hotels, seashore residences, industrial plants and aquariums, but on shipboard as well. The finest and newest ships being built in this country have all-lead soil piping systems with burned joints, which is a new development with shipbuilders here. Such a system gives maximum corrosion resistance with flexibility that can stand the buffeting a ship must take. There may be said to be no joints in such a piping system, for after burning it is one continuous piece of lead pipe. Burned joints require less space than wiped joints, and space is at a premium on shipboard. Because there are so many obstructions to pipe lines on ships, lead has an advantage over rigid pipes because easy bends can be made without joints or special fittings.

Because handling corrosives is such an important part of lead's work where welded joints are concerned, is the reason for the statement made earlier that welds in lead must be 100% right the first time. Much lead welding is repair or patching; even on new work it is most often done in the field under far from ideal working conditions; as soon as the burning is completed, tanks, pipes or whatever the equipment may be are filled with highly corrosive, often dangerous, chemicals. Imperfections in welds would be disastrous, yet there is little opportunity for inspection. For that reason, in the chemical field in particular, lead burners must know how to do perfect jobs with rapidity. That only comes after much practice and experience.

Large Lead Pipe for Acid Handling Is Often Made From Sheet Lead and Welded.

Welded Seams Prevent X-Ray Penetration

X-ray-room linings also require extensive lead welding, and this is another use for the process that is growing rapidly. X-rays are extremely harmful to human beings unless confined to the locality at which they are required. Therefore rooms containing X-ray equipment should be completely, or under certain conditions, partially lined with sheet lead, the only effective, practical material for X-ray insulation. As the rays will penetrate other materials or the slightest openings, burned seams are used on these linings unless certain special types of construction

are used. Even these generally require a considerable amount of shop burning.

Sheet lead is a very important waterproofing material. It is used in bathrooms, swimming and garden pools, conservatories, fountains and many special places. In these cases either soldered or welded seams are used, but those that are welded are many and probably give the best assurance of trouble-free service.

Architectural Lead Work

Recent revival of interest in this country in architectural lead work, such as is so extensively used abroad, has also opened up another fruitful field for lead welding. Much of this work requires no burning or soldering at all, loose-locked seams being used for roofing and flashing to allow for expansion and contraction. But ornamental lead work, crestings, finials, sometimes spandrels and other decorations do require welding, because solder is less durable and because solder would be brighter than

Hard Lead Cresting, in Shedd Aquarium, Chicago, the Joints Being Welded and Scraped.

the surrounding metal and makes seams prominent. It is in this type of work that welded seams are scraped down flush with adjoining metal for the sake of appearance, and because strength is not generally an important factor. The fabrication of hand-wrought lead work such as leader heads, flower boxes, humidors and other devices also requires lead welding to give unobtrusive, durable and moisture-proof joints.

Anti-vibration pads, used under building and machinery foundations, are often made of two sheets of lead enclosing two layers of asbestos. The lead completely envelopes the asbestos and must protect it from moisture. Seams in the lead are generally welded for permanence.

Storage-Battery Manufacture and Repair

Lead welding is an important process in the storage battery industry for welding plate connectors and terminals. Among storage battery manufacturers all this work is done in the factory and is consequently simpler than that done in the field. It makes it possible to use oxygen-city gas flames, which are inexpensive but require slightly larger tips than other lead burning work. Some of the largest manufacturers have also found it advantageous to do the work mechanically, passing the parts on an endless belt conveyor underneath three or four flames of different temperatures which are permanently fixed. Battery repair shops as a general rule also use oxygen-city-gas flames.

One might go on almost ad infinitum describing the less important uses of lead burning. The interesting thing to note is that almost every field of use is an expanding one.

Proposed Chicago Building Code Allows Welded Structures

A new building code for the city of Chicago, which has been under consideration by a committee of builders and architects for the past five years, has been completed and presented to a sub-committee of the Building and Zoning Committee of the City Council. This sub-committee, of which Alderman O'Grady is chairman, holds public hearing on this code on October 19th, following which the sub-committee will report to the full committee. After consideration by the full committee, the proposed code will be put before the council for adoption. If no unforeseen delays arise, the city council should have the report and proposed code in its hands for consideration by the first of the year. That portion of the new code relating to welding follows closely the American Welding Society Code. Arthur W. Rosenthal was chairman of the Committee of Builders and Architects which drew up the code.

Welding of Stainless Steels Is Topic Before Philadelphia Session

J. P. Morrissey, of the Crucible Steel Company of America, presented "The Welding of Stainless Steels" at a well-attended meeting of the Philadelphia Section of the American Welding Society on September 19th.

At the next meeting of the Philadelphia Section, to be held October 17th at the Engineers' Club, Wm. D. Halsey, Assistant Chief Engineer, Boiler Division, The Hartford Steam Boiler Inspection and Insurance Company, will present a talk on "What Is a Good Weld?" R. F. Burke, of the Heine Boiler Company, Inc., and T. M. Jackson, Electrical Engineer, Sun Shipbuilding & Dry Dock Company are to speak on the subject, "How to Weld to Meet the Boiler Code."

Recommendations for Oil-Refining Heat-Exchange Equipment

These recommendations have been approved by the Petroleum Division of the American Society of Mechanical Engineers and have been printed in pamphlet form. They are available at a cost of 50 cents to members of the Society and 75 cents to non-members. These recommendations cover a definite outline of procedure for design, construction practice, and testing of heat-exchange equipment intended for oil-refinery service, in order to provide a uniform standard of comparison for heat-transfer rates in design and on performance test.

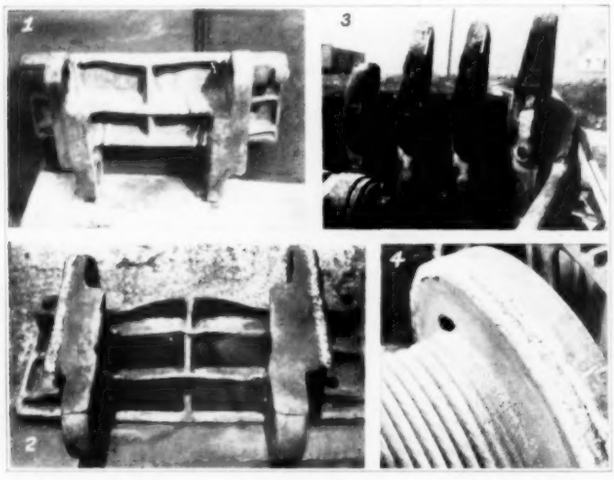
Field Erection of Tanks to Be Topic at Chicago Section A.W.S.

"Plate Fabrication" will be the subject of a talk by H. C. Boardman, of the Chicago Bridge & Iron Works, at the first fall meeting of the Chicago Section of the American Welding Society, to be held in the Palmer House on October 21st, at 7:30 p. m. Mr. Boardman will discuss at considerable length the field erection of tanks and will illustrate his talk with lantern slides. The meeting will be preceded by a dinner at 6:00 o'clock.

Repair-Welding of Large Shovel Saves $4,000 in Replacement Parts

A firm in the East has been operating a large power shovel almost continuously on extremely hard rock, with considerable wear and tear resulting. On taking down the machine with a view to overhauling it, it was estimated that the replacement parts alone, without labor, would cost between $4,000 and $4,500. Among the items to be replaced were worn gears, treads, brake drums, and shaftings.

To save most of this expense, it was decided to rebuild all worn parts and repair all fractures by arc welding.



Figs. 1 and 2. Section of Tread Before and After Repairing. The Track Edges Have Been Built Up and the Fractures Repaired.
Fig. 3. View of 1½-Yard Dipper. Note Tooth Broken Off at Left, and Two Hard-Surfaced Teeth in Center.
Fig. 4. 40-In. Drum, With Undercut Built Up.

After the job was completed, comparison of costs showed a direct saving of approximately $3,000.

The first job was the repairing of 74 treads (see Figures 1 and 2). To replace these would have meant an expenditure of $2,590 at $35 per tread. By using welding to rebuild all these treads and to repair all fractures, the cost averaged only 83 cents per tread.

A number of steel shaftings were worn sufficiently to require repair, so these were built up by depositing metallic-arc metal along the shafts. In some cases the shafts had to be built up as much as ⅛ in. The shafts were then machined to size, and the cost was but a small fraction of the cost of new shaftings.

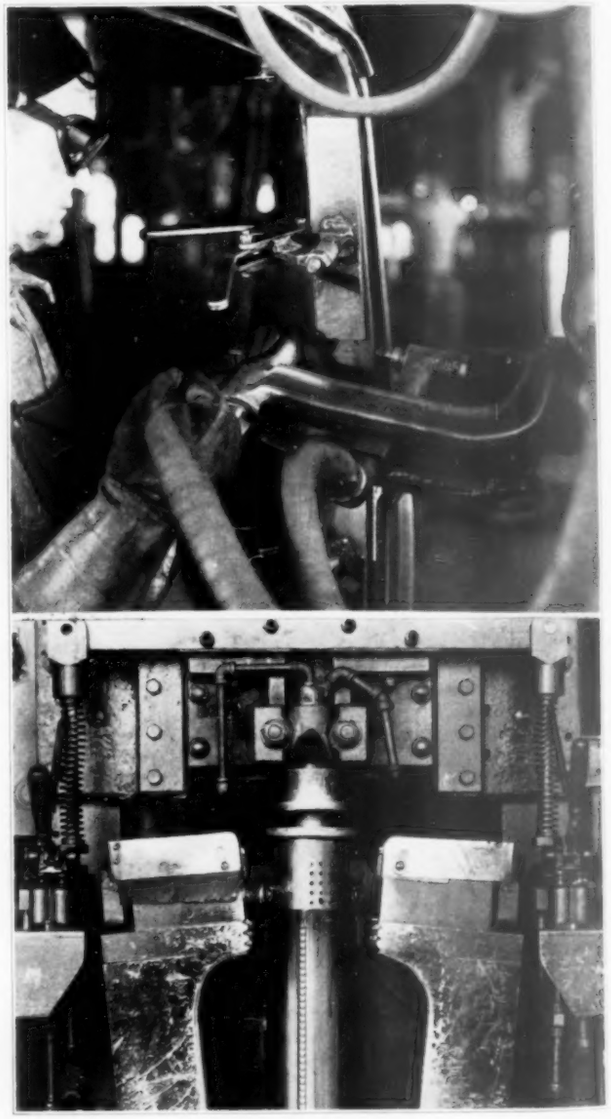
Some idea of the strenuous nature of the work to which this shovel had been subjected is given by Figure 3, in which the heavy manganese-steel tooth on the left has been snapped off at the base. The two white lines shown on the edges of the center teeth represent a welded deposit of austenitic steel, tough and comparatively soft, but when subjected to abrasion or hammering it rapidly wear-hardens. These center teeth had been in fairly continuous use in hard rock for nearly three weeks on the last job. The added hard wear which this hard surfacing gives is shown by comparison with the new tooth on the right, which has been in service only a day and a half. The average life of a tooth is two or three days in this heavy class of work. Quasi-Arc Mangcross electrodes were used to obtain this welded deposit.

Another big saving was effected in the rebuilding of a 40-in.-diameter brake drum, shown in Fig. 4. The circumferential edge was worn 1 to 1½ in. Without any preheating whatsoever, this was built up with electrode material and machined to size.

Some of the structural steel riveted members were found to be cracked and the rivets loose. These also were made fit for service by welding.

Welding in the Manufacture of Dodge Cars

PORTABLE spot or "gun" welders are an example of the new devices and methods being developed and used in the Dodge Brothers Corp. plants. By means of these electric "guns" the front shroud is welded to the body. Compressed air is used as the working agent on these machines, clamping the parts to be welded in place. Making and breaking of the welding circuit is done pneumatically. This shroud is welded to two sides of the front posts, the



(Top) Welding the Cowl or Front Shroud to the Front Posts With a Portable Spot Welder Operated by Compressed Air.
(Bottom) For the Projection-Welding of Mufflers, a Welding Head With Twelve Contacts Is Used.

welder being inserted in slots in the frame girders. The gun welders are rated at 18 kva. and 440 volts.

Another interesting welding machine is that used for the projection-welding of mufflers. This welder has 12

contacts in the welding head with a capacity of 200 kva., 25,000 amperes, at from 6 to 8 volts. In this operation the perforated cone and inner shell are welded to an end cap to form one piece.

An ingenious safety device on this welder makes it impossible for the operator to get his hands caught in the working parts. In order to start the machine, both handles (one on each side of the welding head) must be held down. The machine will not respond to pressure applied to one handle only. As the operator pulls down the two handles simultaneously, the side jaws swing in

This Projection Spot Welder Makes Six Welds in Each End of the Rear Engine Insulator Bracket.

and grip the muffler firmly. The welding head is forced down by compressed air. The pressure builds up on the head until it reaches a limit sufficient to cut in a switch which starts a timing motor and energizes the welding circuit. The motor times the weld, leaving the current on long enough to complete the weld yet not burn the steel. The welder has a capacity of 200 mufflers an hour on a production schedule.

The peculiarly formed rear engine insulator bracket used with "floating power" engine mountings on Dodge cars is welded in six place on each end. It is formed from $\frac{3}{16}$-in. steel. The six welds require a current of 55,000 amperes at from 6 to 8 volts. The rear end of the crankshaft and casing rest on this support, which is bolted to the chassis immediately in front of the gear-shift lever.

In order that the motion of the engine will not be transmitted to the gear-shift lever, the lever is mounted between the tines of two forks, each with two tines. The fork handles are butt-welded to the tines, four at a time in a single operation.

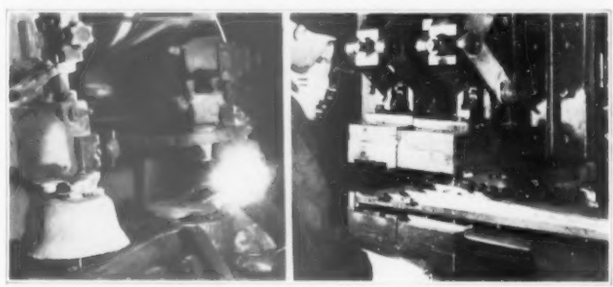
One of the most spectacular of the more recent developments at Dodge is the welding of the rear axle housing. This is done in two operations in a double-ended rear axle arc-welding fixture. The machine has one 60-volt, 400-ampere, compound-wound generator for each arc, driven by its individual motor. Each arc pulls 300 amperes at 26 volts.

Two halves of the housing are placed in the welder and clamped securely in place at the center and ends with special dies operated by compressed air. The seam along which the housing is welded is beveled at a 60-deg. angle during forming. The welding wire is carried on drums, one above and behind each welding head, and is fed down through the head to the arc by the small motor mounted above each head. The armature circuit of the motor is so connected that the length of the arc is maintained nearly constant during welding, the motor controlling the rate of feed of the wire. A large motor, mounted on the carriage in the rear of the welding heads, serves to move the heads horizontally along the seam.

The welds are started at the outside edges of the housing in the first operation and move in along the seam to the center, where the arc is automatically cut off. The welding heads are moved in toward the machine and off the housing, which is turned over and again clamped tight. The welding heads are then moved back out into position over the seam, and the welder again started and the housing welded out to the end.

A projection spot-welder, which differs from the standard spot-welder in the shape of the welding heads, is another Dodge adapation used to attach the ends and support brackets on running boards. Instead of the pointed elements typical of the standard spot-welder this machine has flat, die-shaped welding elements, the work having a small raised spot stamped on it to contact the welding point and start the weld.

This machine is capable of making 25 projection welds in one operation. Some of its features are: an interchangeable set of dies, making it possible to weld four different sizes and shapes of running boards without changing welding heads; splitting the head which carries



(Left) Rear Axle Housings Are Welded by This Double-Ended Arc Welding Fixture. The Nearer Arc Is Just Ready to Start, the Other One Already Being in Operation.
(Right) Ends and Support Brackets Are Attached on Dodge Running Boards by Projection Welding.

the welding contacts; additional transformers to increase the capacity of the machine; and a timing cam.

Running boards for both right and left sides of the six and eight cylinder models are welded on this machine. As the running boards are wider at one end than at the other, two welders are necessary; the boards having 25 welds at the wide end and 23 at the smaller end. Both welders are identical, with the exception of the arrangement of the dies.

The welding head was split in order that positive contact could be had at all the welding points, which fall into two groups on two supports. By splitting the heads each group of welds is assured sufficient pressure to make an efficient joint. The welding heads are nicely balanced on counterpoises.

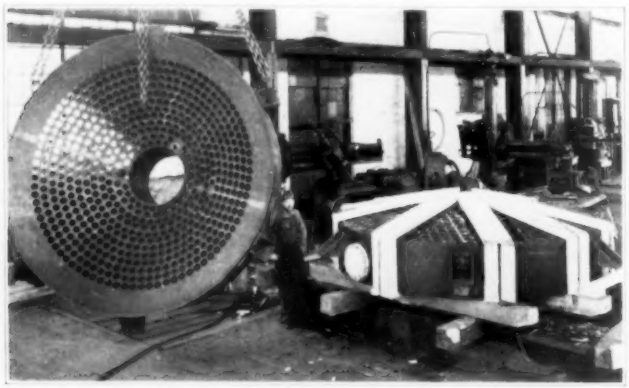
The timing cam turns the welding current on and off the welding points. As the operator starts the machine, the

welding heads press against the work, the cam cuts in the welding circuit, holds it from ¾ to 1 second and then releases it. The welder has a capacity of 400 kva., drawing 50,000 amperes at from 6 to 8 volts.

Welded Sugar-Refining Equipment

By A. C. Keily

The illustration shows two 13-ft. calandrias made by the Chicago Bridge & Iron Co. and the Goslin-Birmingham Manufacturing Co., which are a part of two huge sugar-refining machines to be shipped to the Philippine Islands. These calandrias are electric-arc welded throughout, except that the brass pipe in the center of each is



Welded Calandrias for Sugar-Refining Equipment

held firmly in place by expansion. In service, they are subjected to steam under pressure. The steam evaporates the sugar liquor in the container, and the vapor is carried over to a second evaporator, which finishes the refining process.

Committee to Consider Welding Exhibit for Rosenwald Museum

A committee has been appointed by the American Welding Society to give consideration to what assistance can be rendered officials of the Rosenwald Museum of Science and Industry in Chicago in planning suitable demonstrations of the welding processes for the museum. This committee, all of whose members reside in Chicago, consists of C. C. Whittier, Chairman (also Chairman of the Chicago Section of the A.W.S.), J. I. Banash, W. M. B. Brady, H. S. Card, and E. Lunn. The Rosenwald Museum is a permanent exhibit showing by means of working models and actual demonstrations the application of scientific methods to practically all industries, and is said to be the only museum of this kind outside of continental Europe.

Institution of Welding Engineers Issues Ten Papers on Welding

Ten papers read from October, 1931, to March, 1932, at the sessions of the Institution of Welding Engineers, Ltd., of London, England, have been printed in the Proceedings of the Society. These papers pertain to the welding of lead and its alloys, nickel and its alloys, and copper, as well as the application of welding to boilers, structural steel, aircraft and stainless steels, also carbon arc welding and resistance welding.

Fortune in Incubator Eggs Saved on Unique Job

By R. T. Quick

To save eggs valued at $10,000 in an Iowa hatchery, Henry Malek, of Cedar Rapids, made good use of a principle which has bothered many arc welders. He made the contraction, the drawing together, of two pieces of metal when a bead is laid with an arc, work to his advantage on a job which otherwise would have been hopeless.

This hatchery used a vertical cast-iron boiler to produce heat for the incubator. The boiler consisted simply of a cast-iron jacket around an inner firebox. This boiler had been torn down for repairs. In the rush to get up heat when the job had been completed, the boiler had been fired-up without water. This resulted in a crack completely around the circumference of the outer jacket. A rush job was necessary—$10,000 worth of eggs in the incubator would be utterly ruined if the incubating temperature dropped below the critical point.

Malek was called from Cedar Rapids, 25 miles distant. Upon his arrival with his portable arc machine, he was given just one and a half hours before the critical temperature would be reached. He knew that it would be impossible to lay a bead around more than a third of the circumference in the time given him. He scratched his head and hit upon an idea.

He started with a bead three inches long, skipped six inches, welded three more inches, skipped six, and so on around. The contraction of the weld pulled the crack together, and water was put into the boiler. Although it leaked rapidly, it was possible to bring the heat up sufficiently to save the eggs. The boiler was then drained and the welding of the crack completed.

45-in. Welded Pipe Line To Carry Water Under Water

When the Los Angeles Department of Water and Power decided to build a second dam above the present Mulholland dam, it became necessary to lay a pipe line from the bottom of the new reservoir, through the dam,

This Welded Pipe Line Will Be Submerged 50 Ft. in the Hollywood Reservoir.

along the bed of the first reservoir and down through the canyon where it would connect with the city mains. This welded pipe line, 45 in. in diameter and 3,460 ft. long, will be submerged under 50 ft. of water when the project is completed. The joints are of the bell-and-spigot type and are welded by the shielded-arc process.

Economies of Welded Pipe

By Frank Lane
The Bastian-Blessing Company

From paper read before the Welding Conference at Alabama Polytechnic Institute, May 23-27, 1932

THE acceptance of welded piping as standard practice by architects, building owners, plant engineers and heating contractors has not been due alone to a lower cost of installation, but to increased efficiency, higher strength factors, longer life and other economical advantages of far greater importance than the first cost of the installation.

The economies of welded piping are not confined to the large sizes of pipe, and the use of this construction is rapidly increasing in small home heating systems. Plant officials, engineers, and foremen who have become acquainted with the higher efficiency of welded systems in their industries are demanding the same advantages in their homes and the heating contractors who are prepared with a personnel to meet this demand may be reckoned as the outstanding contractors of your community. The others must follow if they are to survive in business.

The strength of a welded joint in comparison with a screwed joint meets no real controversy. By present-day methods and materials, deposited weld metal has passed an ultimate strength of 70,000 lb. per sq. in. and has reached 80,000 lb. Still further increase may be expected. The best mild-steel pipe will not exceed 55,000 lb. tensile strength, so that we are now prepared to exceed the strength of our base metal by something more than 35% without reinforcing the joint.

Furthermore, the welded joint presents no fissures for concentration of stress. You are all familiar with the care used in the preparation of specimens for tensile-strength tests. Samples are perfectly machined and highly polished to remove tool marks, as any slight groove or notch left by the tool will lower the elongation and ultimate strength of the specimen all out of proportion to the depth of the notch. You have seen the railroad repair gangs notch a heavy steel rail with a chisel and break it off clean with a few blows from a sledge hammer. This same notching and weakening effect is obtained to a high degree by the threading of the pipe.

Threading the pipe is wasteful of material, and sufficient extra material must be provided in the *whole* pipe length to secure the necessary strength at the threaded ends. A 4-in. standard-weight pipe, for instance, has a wall thickness of 0.237 in., which is reduced by threading slightly more than 40% at the point where the screwed fitting stops. In other words, to provide for threading which occurs at relatively infrequent intervals we are using 66% more material and are handling 66% more weight than would be necessary if the system were welded.

There are many installations which, under the present codes, require the use of extra-heavy pipe. These codes are based on the use of screwed fittings and their *inherent weaknesses*. We submit that an all-welded system of standard-weight pipe is superior in strength to a screwed job of extra-heavy pipe. According to Barlow's formula, which is nationally used to determine pipe strength, a 4-in. lap-welded standard-weight steel pipe will sustain 526 lb. working pressure with a factor of safety of 10 to 1. A screwed system of 4-in. extra-heavy pipe under the same formula and factor of safety of the *effective* pipe wall *after threading*, but without considering the notching effect of the thread, will sustain 557 lb. working pressure.

Now let us compare the fittings which would be used in each case. Extra-heavy screwed elbows, tees, and similar fittings are designed for a working pressure up to only 250 lb., whereas welded fittings such as tube turns, forged tees and similar products are of greater strength than the lap-welded pipe.

By employing welding instead of using threaded pipe and fittings, we save 38% in material and 38% in weight and still have a stronger system.

The material and weight savings in fittings are even more pronounced than in the pipe itself. An 8-in. extra-heavy cast-iron flanged elbow with flanges and bolts weighs 329 lb., while a standard 40-deg. tube turn having a safe working pressure of 550 lb. weighs only 45 lb. The erection of this single fitting in the flanged type requires the handling and installation of 37 separate parts having a total weight 631% greater than the single-piece tube turn which is more than twice as strong.

An 8-in. extra-heavy cast-iron flanged tee, with flanges and bolts, weighs 505 lb., while a modern type of forged tee weighs approximately 43 lb. or less than 9% as much as the cast tee. These extra weights mean not only added difficulty in erecting and higher transportation or cartage charges, but also a higher cost for the heavier pipe hangers necessary.

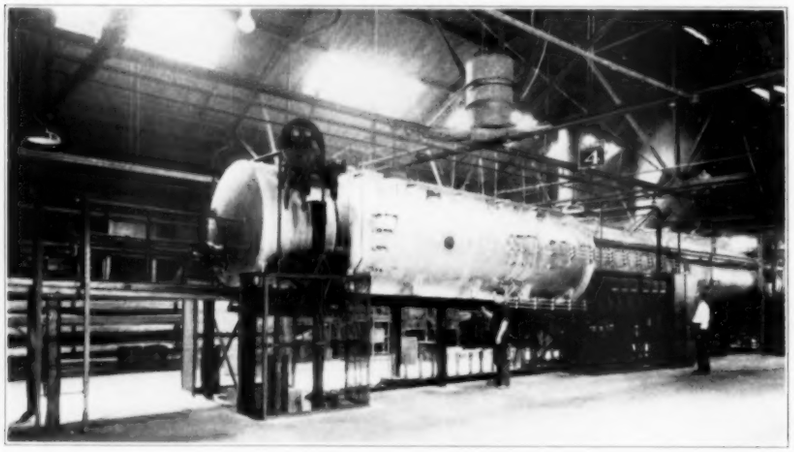
You may question the extra expense of heavier pipe hangers as being immaterial in the cost of a complete job. We believe it is an item to be considered. John Zink, of Baltimore, recently made a careful analysis of the weight savings possible in a complete welded system for a typical pipe installation in a building in Washington, D. C. The figures showed that the welded system as installed weighed 13,500 lb. as compared to a flanged-and-screwed system which would have weighed 27,900 lb. This is a direct saving of 14,400 lb. or more than 51%.

The saving in hanger material for supporting more than seven tons of dead weight distributed over the entire building is an appreciable item and should not be overlooked in considering the advantages of pipe welding.

J. H. Pound, of Rice Institute, recently conducted a series of tests on water flow through 3-in. pipe at velocities from 2¼ to 6 ft. per second and compared the pressure losses for various types of bends. The results showed that a standard screwed elbow created from 75% to 71% greater pressure loss than a tube turn at velocities from 3 to 6 ft. per second. As the pressure loss created by a screwed elbow is approximately equivalent to the pressure loss in a straight 40-ft. run of pipe, it can be readily seen that the efficiency of building piping is largely controlled by the efficiency of the elbows and any improvements which can be made at the changes in direction will directly affect the entire system. These improvements can be made only by welding.

Bundy Adds New Copper Hydrogen Electric Welding Equipment

The Bundy Tubing Company of Detroit has recently announced the installation of a large copper hydrogen electric welding furnace. In copper hydrogen electric welding any number of steel parts having several joints can be welded together simultaneously. The steel parts are closely fitted together, copper powder or copper wire is laid around the joints and the article is then passed through an electric furnace, which is kept at a temperature somewhat higher than the melting point of copper, and in which a reducing atmosphere is constantly maintained.



Bundy's New Copper Hydrogen Electric Welding Furnace.

The steel surface is first thoroughly deoxidized, the copper then melts and flows over the steel and into the joints. The iron and the copper next alloy together, some of the copper goes in solid solution in the steel, and some of the iron is dissolved by the copper to produce an integral alloy bond between the parts to be welded. The article is then cooled, also in a reducing atmosphere, thus preserving a clean steel surface, and the copper solidifies giving a strong continuous weld. Aiding the copper to flow completely through the joint to give a continuous, gas tight weld are the mutual affinity of copper for iron and of iron for copper, capillary attraction, the uniform temperature of the steel, and the deoxidized condition of the steel surface.

The new Bundy hydrogen electric furnace is of the semi-continuous pusher type and is entirely automatic. The entire unit is built in a steel shell six feet in diameter and approximately 82 ft. long, the first 20 ft. being the heating chamber, which is bricked in the shell, and the next 60 ft. the cooler, which is jacketed for water cooling. In order to minimize heat losses into the cooler, the heating chamber and the cooler are connected by a rectangular throat which is built of fire brick and insulation. The dimensions of the throat, limit the size of the work that can be sent through the furnace to 17"x13"x30".

The reducing gas is fed into the heating chamber at a point near the throat and flows out through the charging and discharging openings at both ends of the furnace. Nichrome ribbon resistors are mounted in loops on the side walls and on the floor of the heating chamber.

The work is carried on cars 2 ft. long, which are loaded on a lower conveyor running underneath the entire length of the furnace, and are pushed through the furnace on another double track disc-wheel alloy conveyor in a lower temperature chamber built beneath the floor of the heating chamber. The work is brought into the heat zone on supports which extend up from the cars through a longitudinal opening in the floor of the heating chamber.

An elevator at each end of the furnace brings the cars to the level of the upper and lower conveyors, and hydraulic pushers alternately move the train of cars on the conveyors one car length, and push the last car on the charging or on the discharging elevator.

Copper hydrogen welding produces gas tight joints, good heat conductivity through the joints, ductility and strength. Due to the relatively high temperature of the process the steel is thoroughly annealed, is free from localized strains, and has clean, inside and outside, surfaces free from scales and oxides. Due to the high melting point of the welding metal the steel can be heat treated, or can be used at elevated temperatures without affecting the welds.

Articles that can be welded in a furnace of this type are almost unlimited. For instance, castings and forgings of very intricate designs can be made more economically by simply assembling together separate stampings of proper design and copper welding them in a hydrogen electric furnace.

This process is particularly adopted for the automotive and the refrigerating industry.

A few of the welded parts that the Bundy Tubing Company is now in a position to furnish are evaporators, condensers, receiver tanks, floats, in short almost any assembly composed of two or more parts.

Black, Sivalls & Bryson Move Headquarters to Oklahoma City

Black, Sivalls & Bryson, Inc., have moved their general offices from Bartlesville, Okla., to their own new office building, located at 2131 Westwood Blvd., Oklahoma City. The general offices of B. S. & B. and its manufacturing subsidiary are now consolidated in the same building. The general offices of this company have been located in Bartlesville since 1904. Because of the erection of the American Tank & Equipment Corporation's new plant at Oklahoma City, it was decided to merge the general offices of the two companies for greater efficiency and economy. Furthermore, the present new quarters are more accessible and convenient to nearly all points in the Mid-continent field.

Several years ago Black, Sivalls & Bryson, Inc., purchased the American Tank Company of Oklahoma City, and built a new, modern welding plant, which building is an all welded structure. This plant is the only one west of the Mississippi River, which is in position to fabricate and anneal high pressure, high temperature vessels used in the refinery industry.

The name of the subsidiary company was changed to the American Tank & Equipment Corporation because the company was manufacturing the oil and gas separators, high pressure vessels, and other equipment, in addition to the welded tanks. The parent company manufactures wood, and bolted steel tanks. The entire line is distributed through branches conveniently located to most active fields.

Most of the employees in the Bartlesville office were transferred to Oklahoma City at its removal on July 5th, and the present personnel of the general office includes, among others: H. E. Partch, Asst. Secy. and Asst. Treas.; Budd Parks, General Auditor; Lloyd Harding, Credit Manager; W. F. Gates, Purchasing Agent; A. W. Jenkins, Traffic Manager; F. L. Giles, Billing Clerk; Walter Lutke, Cost Clerk; Geo. Stevens, Bookkeeper; Lloyd Young, Machine Operator; Donald Torr, Cost Clerk; R. T. Shaffer, Payroll Clerk.

Eisler Electric Head on European Trip

Charles Eisler, President of the Eisler Electric Corporation, Newark manufacturers of machinery for the production of incandescent lamps, radio tubes, neon signs, electric welding machines, and Eisler Oil Burners, sailed for Europe on August 30th. Mr. Eisler intends to visit Austria, Hungary, Switzerland, Holland, Belgium, Germany, England, Jugoslavia, Czecho-Slovakia, Spain, Sweden, Poland, France, Italy, and Russia. From various inquiries received from the above countries, he believes that business should be larger for the coming year from the European countries.

Exhibit of Air Reduction Sales Co. Wins Prize at Buffalo

At the Buffalo exhibit of the National Metal Congress and Exposition, the Air Reduction Sales Company was awarded a loving cup for having the second most interesting display, in the judgment of the committee of five appointed by the mayor of Buffalo who made the awards. First prize was awarded the Jones & Laughlin Steel Corporation and third prize went to the Grasselli Chemical Company. The awards were authorized by the board of directors of the American Society for Steel Treating.

J. I. Banash Heads National Safety Council

The Executive Committee of the National Safety Council has announced the new officers of the Council, among which is J. I. Banash, incoming president. Mr. Banash is widely known in the welding field, and is consulting engineer for the International Acetylene Association. Before establishing his consulting practice in Chicago, he was for twelve years with the Underwriters Laboratories. He has specialized in fire and accident prevention in their relation to the physical and chemical sciences, and has recently achieved prominence for his work with

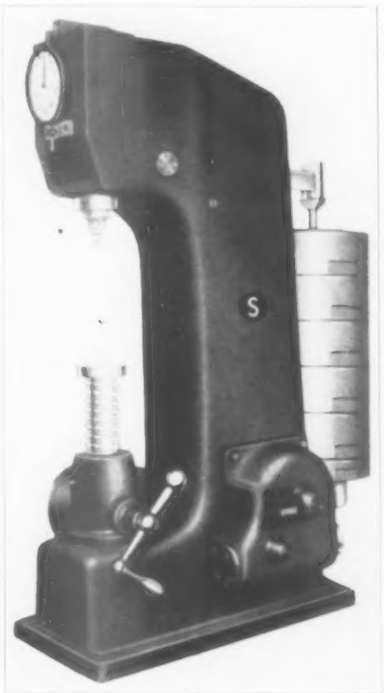
artificial atmospheres high in oxygen, in relation to therapeutic applications. He has taken an active part in the activities of the American Welding Society and other engineering and research organizations.

New Hard Facing Rod Announced by Whelite

Whelite Hard-Nox rods have been developed for hard-facing applications and can be applied by either the electric arc or the oxy-acetylene torch. They are recommended for building up heavy hammers, rollers, picks and in other applications where extreme toughness is a desirable characteristic of the deposited metal, and for building up heavy tools with tungsten diamonds. Whelite Distributors, 1737 E. Seventh St., Los Angeles, Calif., who are putting these rods on the market, claim that Whelite Hard-Nox can be immediately quenched in cold water without damage and will not crack or chip.

New Machine for Testing Brinell Hardness

A new Brinell hardness testing machine which operates by the dead-weight system of applying the load instead of by hydraulics has been announced by the Steel City Testing



Laboratory, 8843 Livernois Ave., Detroit, Mich. The design makes it possible to incorporate a depth measuring device which in conjunction with a moveable scale permits hardness tests to be made quickly and read directly without the use of a Brinell microscope. The screw table is elevated and lowered by a quick crank adjustment. This machine is known as the "Superior" model UK-300 and is driven by an electric motor with push-button control.

New FlexArc A. C. Welder

A new 100-ampere FlexArc A.C. welder is described in a new leaflet published by the Westinghouse Electric & Manufacturing Company. Rated at 220-440 volts, 50-60 cycles, single phase with a current range of 4 to 125 amperes, this welder meets the great demand for the economical arc welding of thin-gage material such as that encountered in the manufacture of metal furniture, sheet-steel cabinets and containers, in aircraft fabrication work, job and garage repair work, and in the fabrication and erection of ventilating systems and materials-handling equipment of many kinds. The leaflet describes the construction, operation, and distinctive features of this new welder.

Arcos Announces "Exelend" Electrode

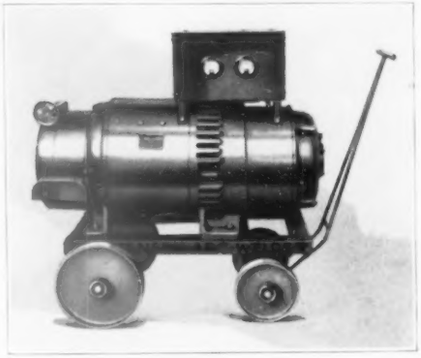
Announcement has been received from Arcos, Inc., Philadelphia, Pa., of the production of a new electrode known as "Exelend". This is a heavy-flux-coated electrode which the makers claim will deposit high-quality weld metal in all positions. It is stated that the slag removes easily and that the work can be handled easily by any operator who is proficient with heavy-covered electrodes. The company has also issued a new bulletin describing the complete Arcos line.

G-E Demonstrates New Automatic Welding Head

A new welding head, developed by General Electric engineers for automatically welding with heavily coated electrode, was demonstrated at the Schenectady plant of the company on September 27th and 28th. This new equipment contains a special device for conducting the current to the electrode. It will handle heavily coated electrode up to $\frac{5}{8}$ in. diameter in size and is rated up to 600 amperes. It can also be adapted for larger electrode and heavier currents by modifications in design.

New Gasoline Driven P & H Hansen Arc Welder

A newcomer in the construction field is the new P & H Hansen gasoline driven arc welder just announced by the Harnischfeger Corporation, 4404 W. National Ave., Milwaukee, Wis. This unit is built for quick accessibility and



can be hooked onto a truck or pleasure car and pulled to the location of the work and can also be supplied in the stationary type.

These welders are available in 100, 200, 300, 400 and 600 ampere sizes in either the stationary or portable type. They are powered with Waukesha engines which operate at 1750 r.p.m. The large radiator insures ample cooling capacity, and self-starters eliminate cranking.

Each generator has its own panel board, and the welding current is regulated through a control mounted on the commutator end. If desired, an auxiliary generator can be mounted on the end of the welding generator to furnish 125-volt direct current for light and tool operation.

Champion Rivet Company Enters Welding Field

An automatic welding device is being introduced by the Champion Rivet Company, of Cleveland, Ohio, marking this company's introduction into the welding field. This device consists of arms extended from a bus bar so arranged that as an electric current passes through these arms, the electrode which has been attached to the work gradually consumes itself, and no effort on the part of the operator is required. This machine is referred to as a "self-consumer" and is said to offer great possibilities in the welding of storage tanks and pressure vessels where longitudinal seams are prominent. The length of the seam plays no part, as with the proper arrangement of contacts a rod of any length can be used. The device is also applicable to steel building construction.

John Huntington Polytechnic Offers Courses in Welding

Welding Engineering I and II, the latter being an advanced course, and also a summer course in Welding Engineering, are among the courses offered by the John Huntington Polytechnic Institute, 2341 Carnegie Ave., Cleveland, Ohio, for the school year 1932-1933. E. W. P. Smith is the instructor in these subjects.

Welding Engineering I includes the fundamentals of arc and gas welding, resistance welding and thermit welding. In the advanced course, the student is trained in the practical application of welding in structural design.

Descriptive Folder on Metal Spray Process and Application

Equipment used in metal spraying and the process itself are described in an illustrated four-page folder issued by the De Laval Pacific Company, 61 Beale St., San Francisco, Calif., exclusive Pacific Coast distributors for the Metal Spray Company. Valuable information is given on capacities of different guns when used with different metals, as well as costs.

Arc Welding on Tramways

In a 20-page booklet bearing the above title, the Murex Welding Processes, Ltd., Ferry Lane Works, Forest Road, London, E 17, England, describes arc welding as applied to rails and rolling stock. Particular attention is given to the welding of fish plates, and results of tests are given. The booklet concludes with a discussion of the structure of welds made with Rolex and manganese electrodes.

Folder Describes Welded Framework of Addition to Murex Factory

The design and welding of the steel frame to the extension of the Walthamstow factory of Murex Welding Processes, Limited, of London, are described in a reprint folder issued by this company. This building is 231 ft. long and 160 ft. wide. Drawings and photographs show some of the details of design. The structural work was laid out for the maximum of shop welding and to avoid overhead and vertical welding as much as possible.

G-E Issues Catalogue on Electrodes and Accessories

An illustrated 16-page catalogue has been issued by the General Electric Co., Schenectady, N. Y., on their electrodes for automatic welding, general-purpose welding and cast-iron welding, and heavily coated electrodes for obtaining welds of such characteristics as to meet the requirements of the A.S.M.E. Boiler Code for Class 1 vessels. Information is also given on electrodes for building up hard surfaces. Helmets, hand shields, welders' glass, electrode holders, welding cable and other accessories are described.

New Folder Describes Torches For Soldering and Brazing

A folder describing Prest-O-Lite torches and torch outfits for soldering, brazing and heating has been published by The Linde Air Products Co., New York City. The range of applications and types of work for which this equipment is designed are described in detail, and information is given on Prest-O-Lite gas, with which these torches are used.

Booklet on Welded Underground Pipe Lines

A 15-page booklet, replete with many interesting illustrations showing construction of oil and pipe lines by electric and oxy-acetylene welding, has been issued by Smith Brothers Construction Corporation, 600 Walsix Bldg., Kansas City, Mo.

Brief News of the Industry

About fifty American welders, together with pipe-line workers and superintendents, sailed from New York recently on a vessel carrying pipe and welding equipment, for work on the 1,200-mile Iraq pipe line. This line, of 12¾-in. diameter pipe, will be welded by the electric-arc process.

The General Electric Company has recalled all its available electric welders for the work of increasing production of boiler units for their new oil-burning furnace. The company announces that in order to meet present demands on these furnaces, production has been stepped up to 100%.

A welded pipe line 46 miles in length has just been completed from the Port Barre oil field in Louisiana to a point on the Mississippi River just opposite Baton Rouge, where it connects with storage facilities for loading river boats. The pipe line, a combination of 4 and 6-in. pipe was all-acetylene welded.

The Metallizing Company of America, Inc., Los Angeles, Cal., announce the recent appointment of the Hyatt Metallizing & Manufacturing Company, of San Diego, as exclusive distributors of their products in Imperial and San Diego Counties.

The Los Angeles district office of the Linde Air Products Company, until recently located at 1310 Santee St., has been moved to 2305 East 52nd St., where new and larger quarters have been built. The new location is more conveniently situated to the industrial district.

Welding will be employed extensively in the erection at an early date of a dry-ice plant at McIntosh, New Mexico. Carbon dioxide, which is used in the manufacture of dry ice, was recently discovered while drilling a "wild cat" oil well in the Estancia Valley, 56 miles east of Albuquerque. This provides an entirely new industry for New Mexico. Welded storage tanks and extensive piping systems are required in the construction of these plants.

J. E. McFate, formerly associated with the Jones & Laughlin Steel Corporation, has been appointed a sales representative of the Republic Steel Corporation, Youngstown, Ohio, in the New England territory. Mr. McFate's headquarters will be in Boston.

The Frank Wiggins Trade School, Los Angeles, Cal., recently opened its fall term of the evening school with an attendance in the welding department of 32 students. Two classes are conducted with Willis P. Fisher and J. V. Smith as instructors, and John G. Miller, as principal.

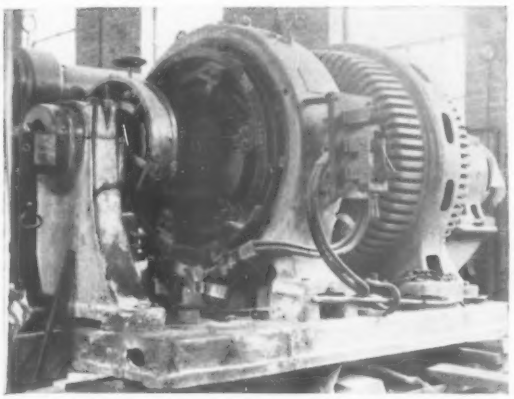
The Isley Iron Works, of Los Angeles, Cal., recently built a practical truck body for transporting their electric welding unit to field jobs. In this body is also incorporated a grinder, hand forge and other convenient features, all of welded construction and secured to the floor of the body. The whole unit is easily lifted by a crane from the truck when not in use, and reloaded in a few minutes' time.

The Canada Wire & Cable Company have made arrangements with the Mueller Brass Company, of Port Huron, Mich., to manufacture and sell "streamline" brass fittings and copper pipe in Canada, according to a report. Manufacture will begin by the Canadian company as soon as machinery can be installed. The company has plants in Toronto, Hamilton and Montreal East.

The machine shop of F. H. Weiss, Le Center, Minn., was destroyed in a fire that swept the shop, destroying a light plant, mechanics' outfit, blacksmith's outfit, a number of gas engines and other equipment. Mr. Weiss is making plans to rebuild.

The Iowa Packing Co., Des Moines, Iowa, has completed plans for a one-story, fireproof structure, 74x96 ft., to house a machine and welding shop and garage. The structure is to be erected this fall and will care for the firm's rolling and other equipment.

Base plate of electric generator repair-welded in 10 *hours* with Tobin Bronze



Electric generator in place on base plate which was fractured and repair-welded with Tobin Bronze by Toronto Welding Co.

Picture above shows the finished welds which were approximately 7 ft. long and varied from ¼" to 3" in thickness.

TWO CORNERS of the base plate supporting a large generator were completely broken off. Without dismantling the equipment, the fractures were repair-welded with Tobin Bronze.

In assembling the broken parts for welding the extreme point of one fractured corner was dropped $^{3}/_{8}$" to allow for contraction. Then the metal along the break was melted to form a 90° chamfer. When the edges of the chamfer had been coated with Tobin Bronze, the weld was begun at some distance from one end of the crack and continued to about the same distance from the other end, additional courses of bronze being applied until all but the ends of the crack were built up flush with the top surface of the casting. After the weld area had contracted, the base plate was perfectly level.

Without further preparation, the ends of the crack were then welded. The second fractured corner was repair-welded in the same manner. Preparation and welding of this unusual job required ten hours' time and 50 lbs. of Tobin Bronze.

The unvarying high quality of Anaconda Copper Alloy Rods is due to the technical experience gained in developing a complete line for low temperature welding—gas and electric. Anaconda Rods are available through leading distributors... usually shipped in bulk, but also obtainable in clearly labeled ten-pound packages. For complete information, ask for Publication B-13.

There is a suitable Anaconda Filler Rod for every bronze-welding purpose. Principal Anaconda Welding Rods, with their melting points, are listed below:

for oxy-acetylene welding

Tobin Bronze*	1625° F
Manganese Bronze	1598° F
Brazing Metal	1634° F
Electrolytic Copper	1981° F
Silicon Copper	1981° F
Phosphor Bronze	1922° F
Everdur*	1866° F

for arc welding

Silicon Copper	1981° F
Phosphor Bronze	1922° F
Everdur*	1866° F

*Reg. U. S. Pat. Off.

ANACONDA
from mine to consumer

THE AMERICAN BRASS COMPANY

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ANACONDA WELDING RODS

Classified Ads

Help Wanted—75c per line, minimum 4 lines.
Jobs Wanted—4 lines free.
Other Ads—$1.00 per line, minimum 4 lines.
Count 8 words to line. Add 6 words for keyed address.

FOR SALE

For Sale—Bargains—Arc Welders, gasoline or electric drive. 30 days trial. Terms if desired. Write Ken's Equipment Exchange, Box U 821, Troy, Ohio.

For Sale—2 Lincoln arc welders, direct current, 200 amperes; 2 G-E automatic head welders; 1 Lincoln seam welder, automatic, with clamping device. Mitchell Supply Co., 225 S. Third St., Minneapolis, Minn.

For Sale—One 400-ampere Westinghouse welding generator and one Westinghouse Weldomatic. This equipment is like new, having been used for experimental work only, and is priced 50 cents on the dollar. R. C. Fisher, 3738 S. Lafayette St., Fort Wayne, Ind.

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